US 20140085267A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2014/0085267 A1

(43) Pub. Date: Mar. 27, 2014

AHN et al.

(54) **HYBRID TOUCH PANEL, HYBRID TOUCH SCREEN APPARATUS, AND METHOD OF DRIVING THE HYBRID TOUCH PANEL**

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(21) Appl. No.: **14/018,610**

(22) Filed: **Sep. 5, 2013**

(30) **Foreign Application Priority Data**

Sep. 27, 2012 (KR) 10-2012-0108264

Publication Classification

(51) **Int. Cl.**
G06F 3/042 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0421*** (2013.01)
USPC **345/175**

(57) **ABSTRACT**

A touch panel includes a sensing unit having a first sub sensing unit configured to output a first sensing current in response to a voltage of a first gate line and configured to reset in response to a voltage of a second gate line the first sensing current corresponding to a first touch type, and a second sub sensing unit configured to output a second sensing current in response to a voltage of a third gate line and configured to reset in response to a voltage of a fourth gate line, the second sensing current corresponding to a second touch type which is different than the first touch type, a display unit configured to generate an image voltage corresponding to image data to be displayed, in response to at least one of the voltages of the first to fourth gate lines and liquid crystal.

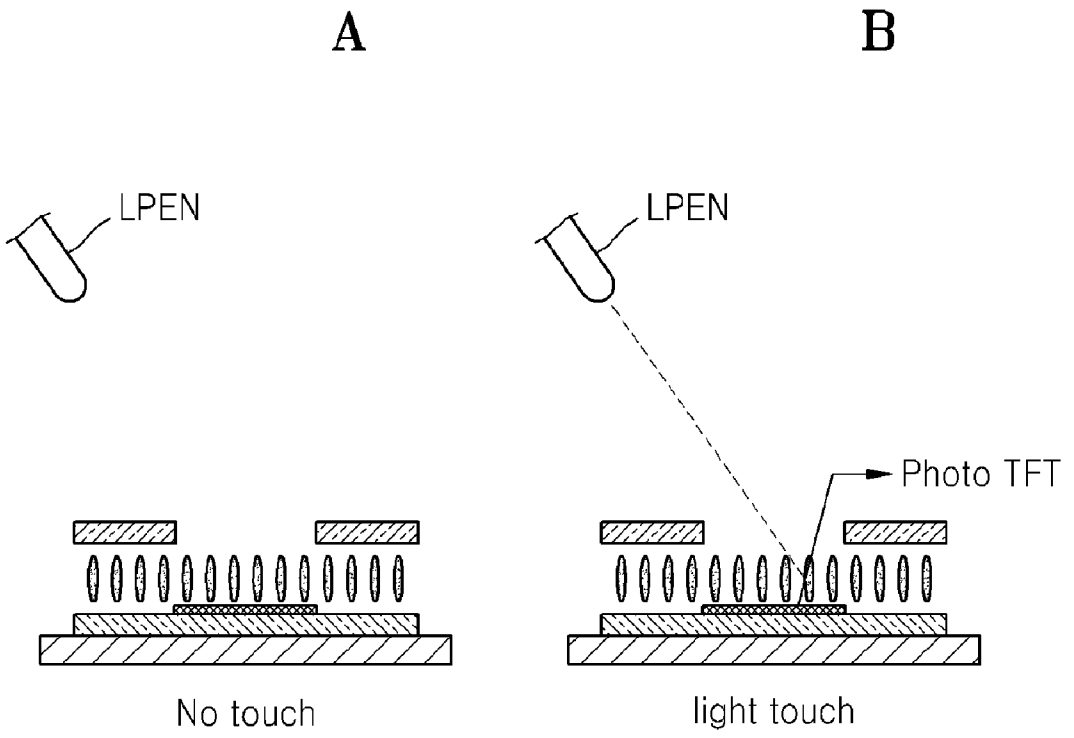


FIG. 1

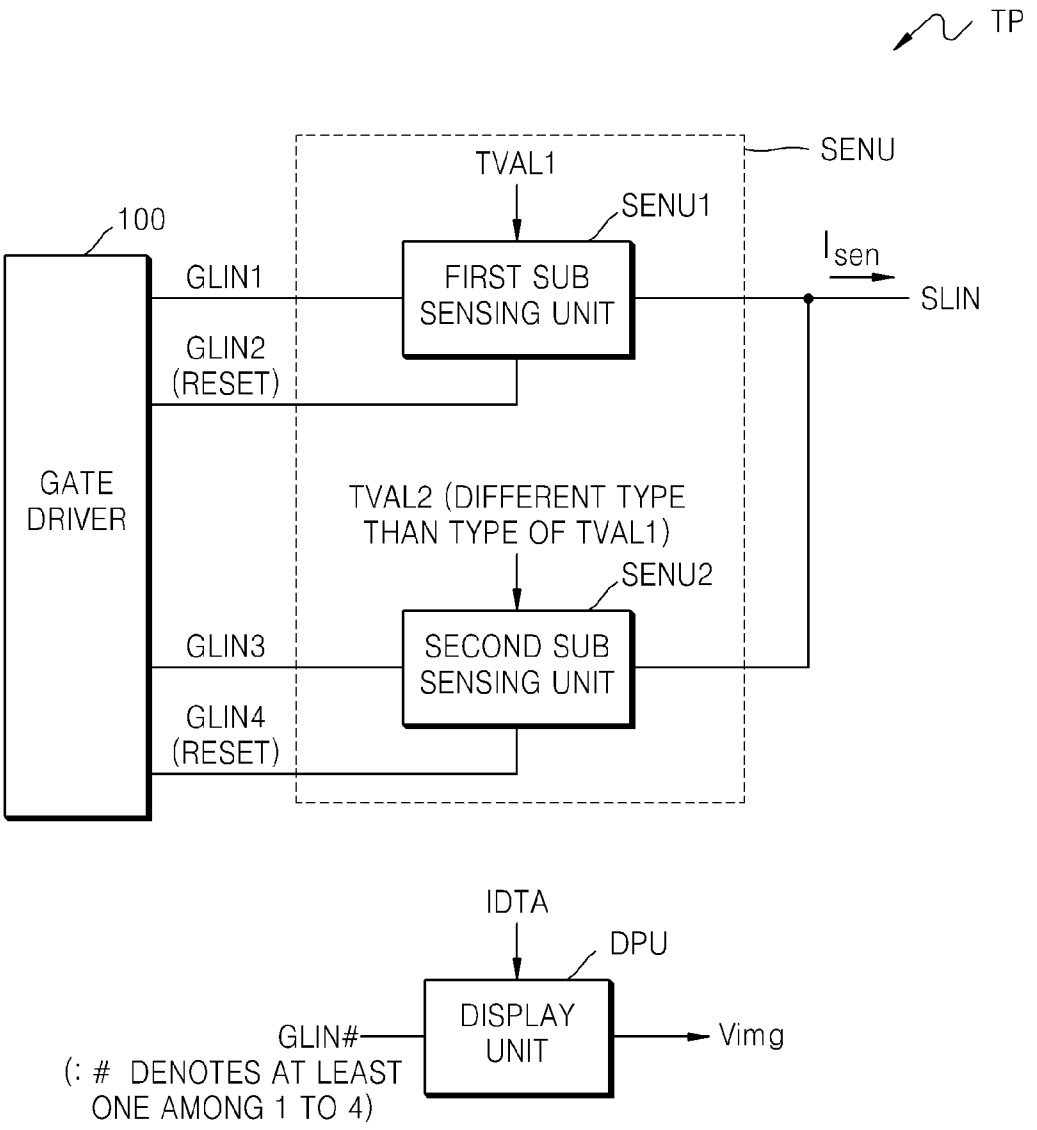

TP
SENU
TVAL1
SENU1
100
GLIN1
FIRST SUB SENSING UNIT
I_{sen}
SLIN
GLIN2 (RESET)
GATE DRIVER
TVAL2 (DIFFERENT TYPE THAN TYPE OF TVAL1)
SENU2
GLIN3
SECOND SUB SENSING UNIT
GLIN4 (RESET)
IDTA
DPU
DISPLAY UNIT
Vimg
GLIN#
(: # DENOTES AT LEAST ONE AMONG 1 TO 4)

FIG. 2A

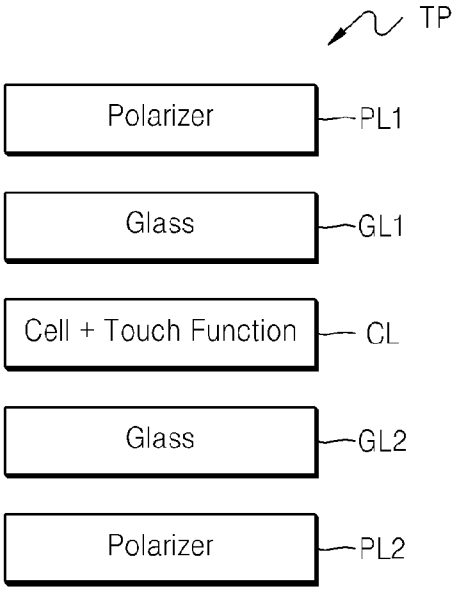

TP
Polarizer
PL1
Glass
GL1
Cell + Touch Function
CL
Glass
GL2
Polarizer
PL2

FIG. 2B

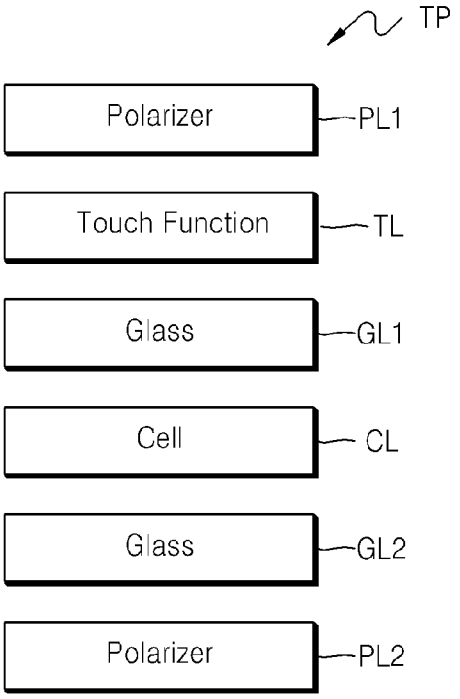

TP
Polarizer
PL1
Touch Function
TL
Glass
GL1
Cell
CL
Glass
GL2
Polarizer
PL2

FIG. 3A

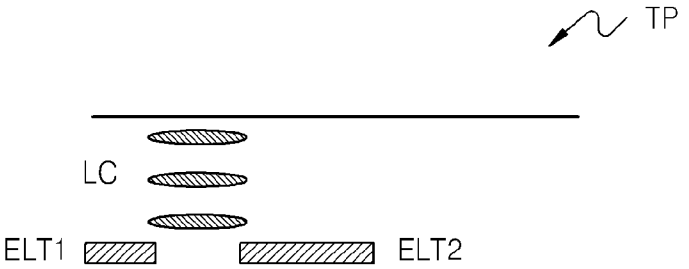


FIG. 3B

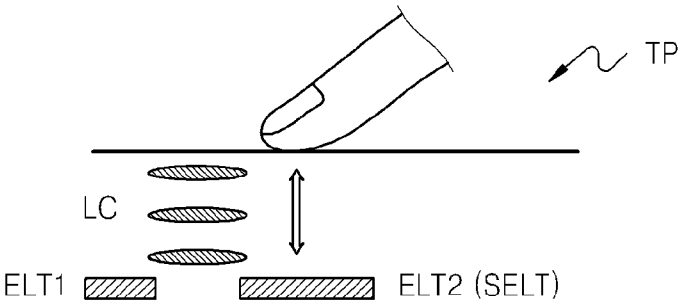


FIG. 4A

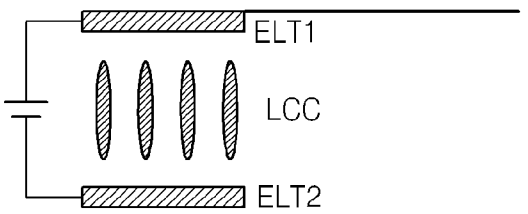


FIG. 4B

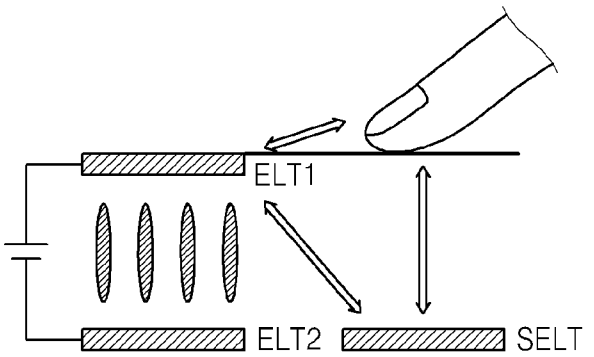


FIG. 5

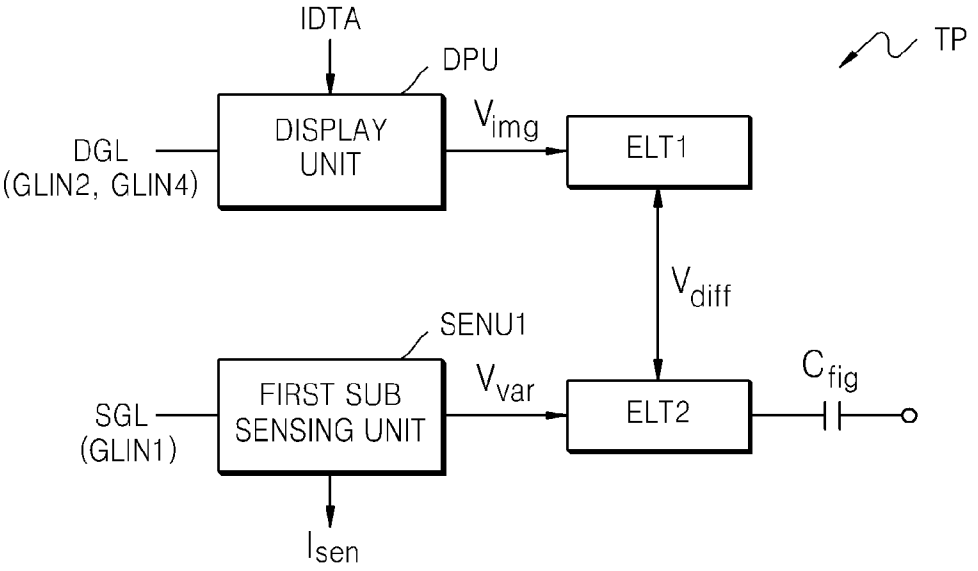

IDTA
DPU
TP
DISPLAY UNIT
V_{img}
ELT1
DGL (GLIN2, GLIN4)
V_{diff}
SENU1
FIRST SUB SENSING UNIT
V_{var}
ELT2
C_{fig}
SGL (GLIN1)
I_{sen}

FIG. 6

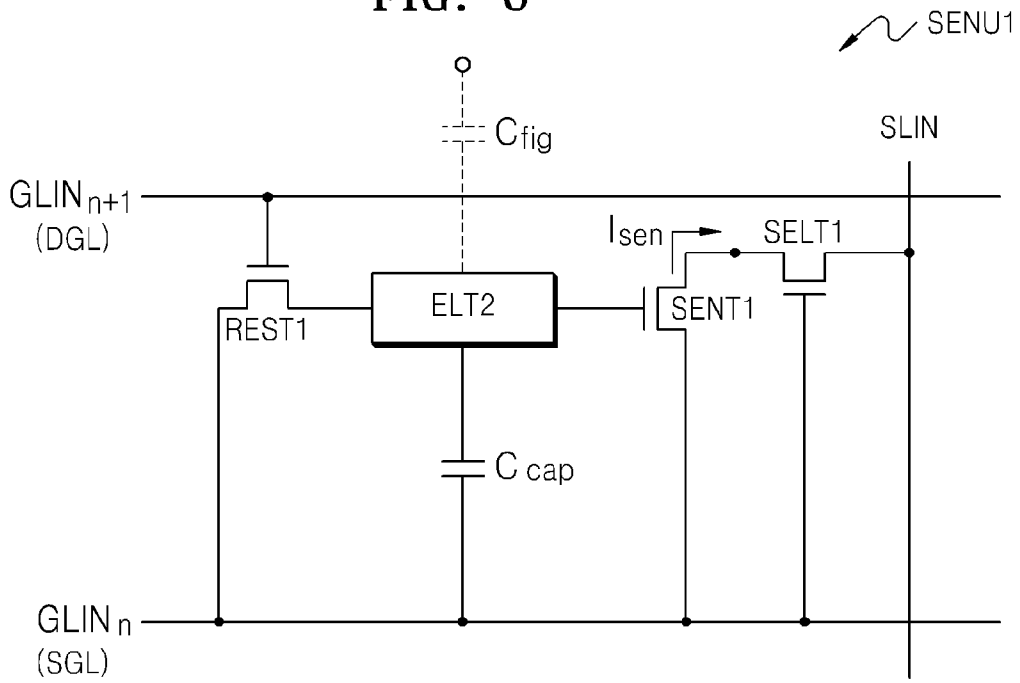

SENU1
C_{fig}
SLIN
$GLIN_{n+1}$ (DGL)
I_{sen}
SELT1
REST1
ELT2
SENT1
C_{cap}
$GLIN_n$ (SGL)

FIG. 7

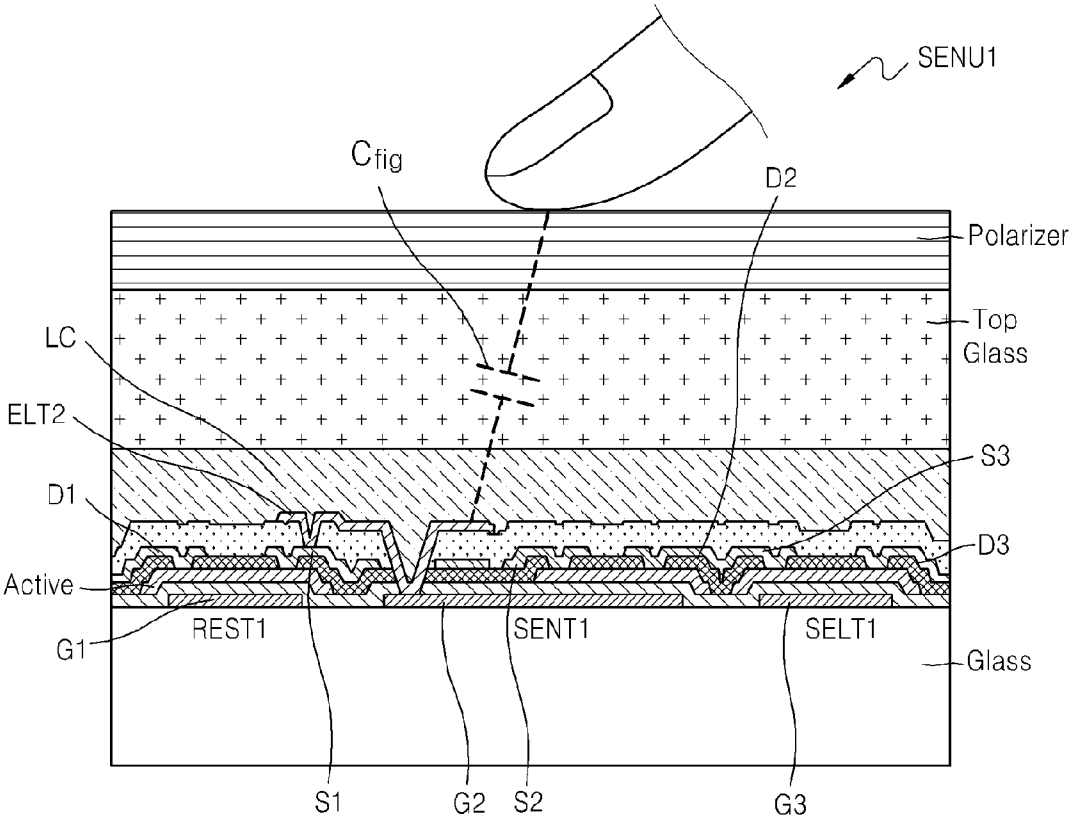

SENU1
Cfig
D2
Polarizer
Top
Glass
LC
ELT2
D1
S3
D3
Active
G1
REST1
SENT1
SELT1
Glass
S1
G2
S2
G3

FIG. 8

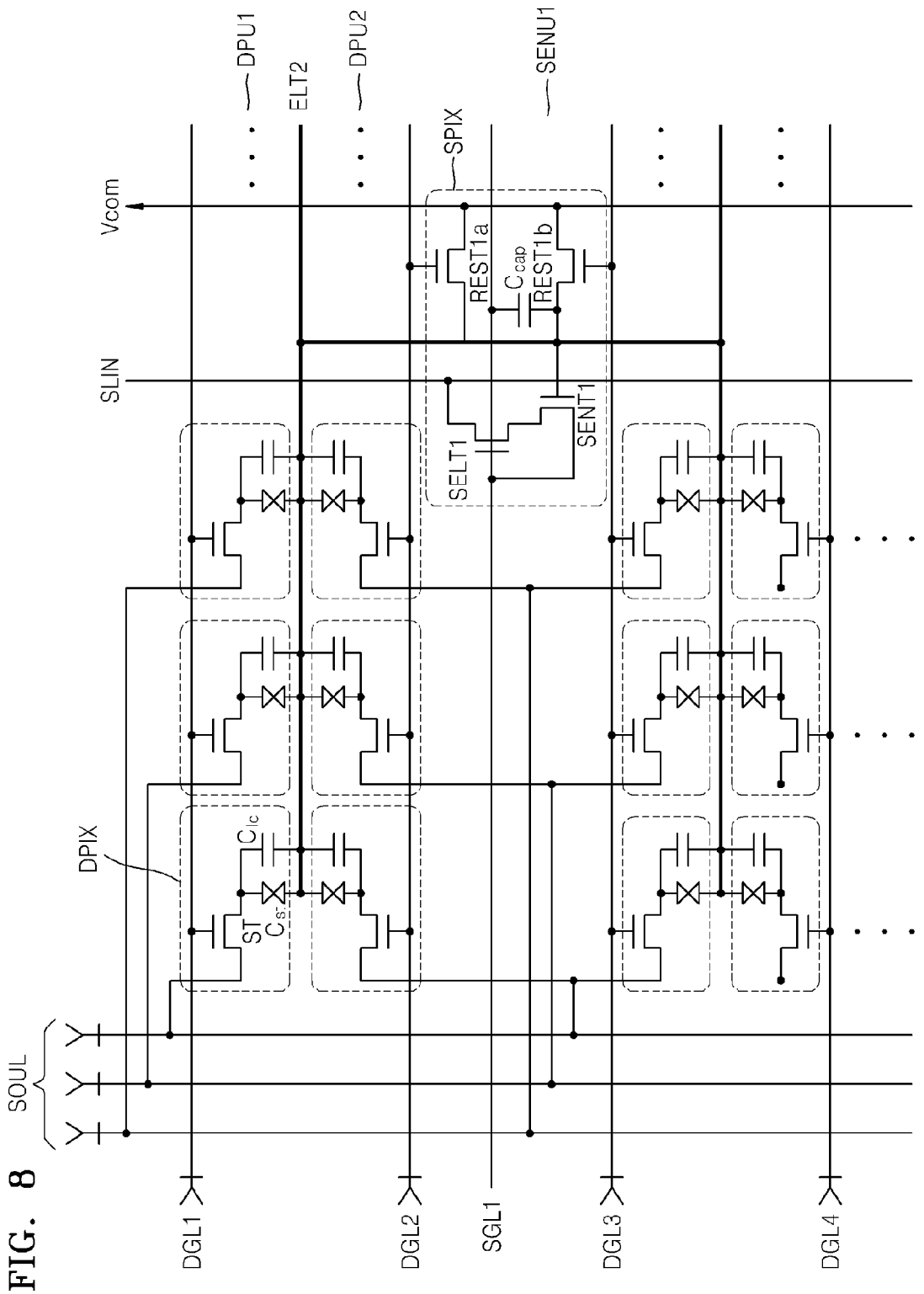

DPU1
ELT2
DPU2
SENU1
SPIX
Vcom
REST1a
Ccap
REST1b
SLIN
SELT1
SENT1
DPIX
Clc
ST
Cst
SOUL
DGL1
DGL2
SGL1
DGL3
DGL4

FIG. 9

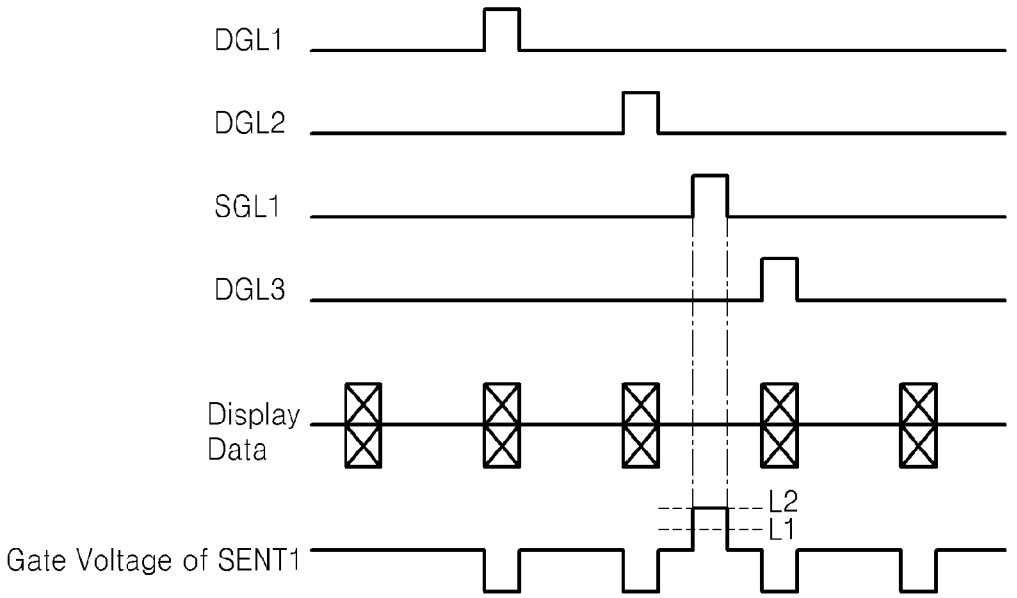


FIG. 10

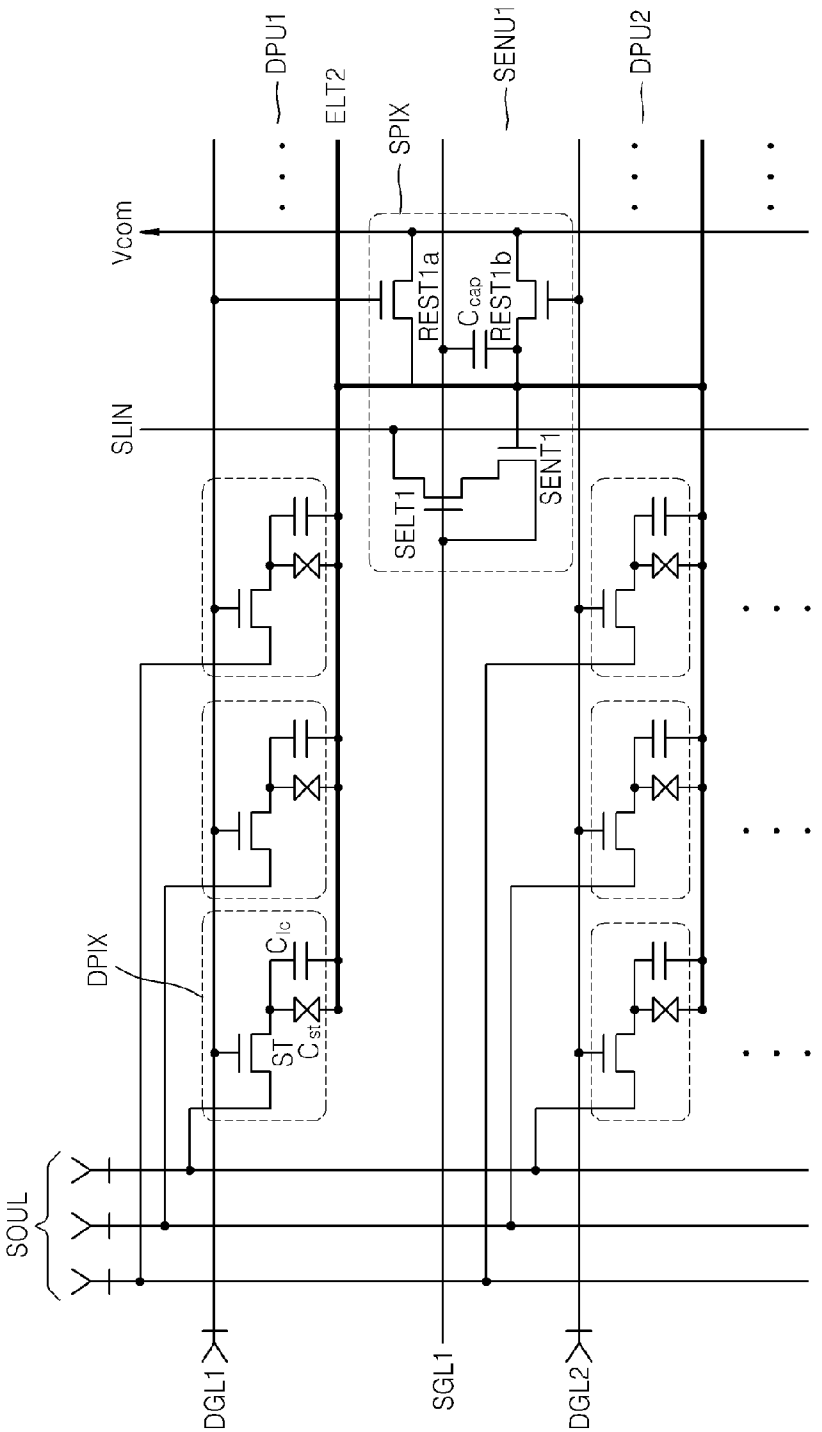
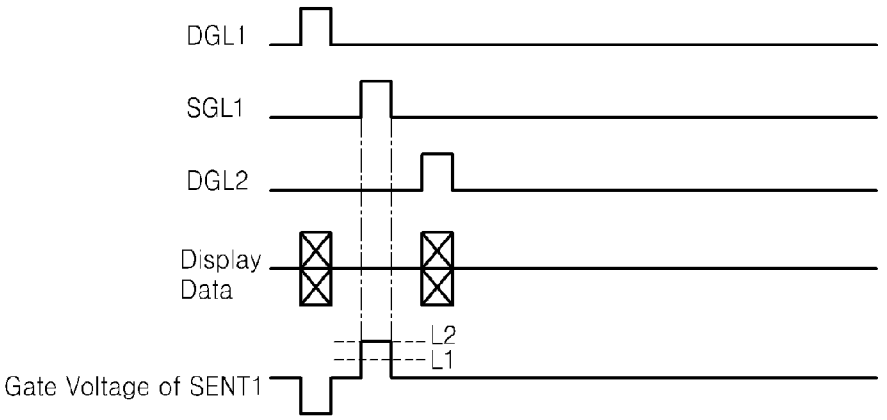

DPU1
ELT2
SPIX
SENU1
DPU2
Vcom
REST1a
Ccap
REST1b
SLIN
SELT1
SENT1
DPIX
Clc
ST
Cst
SOUL
DGL1
SGL1
DGL2

FIG. 11



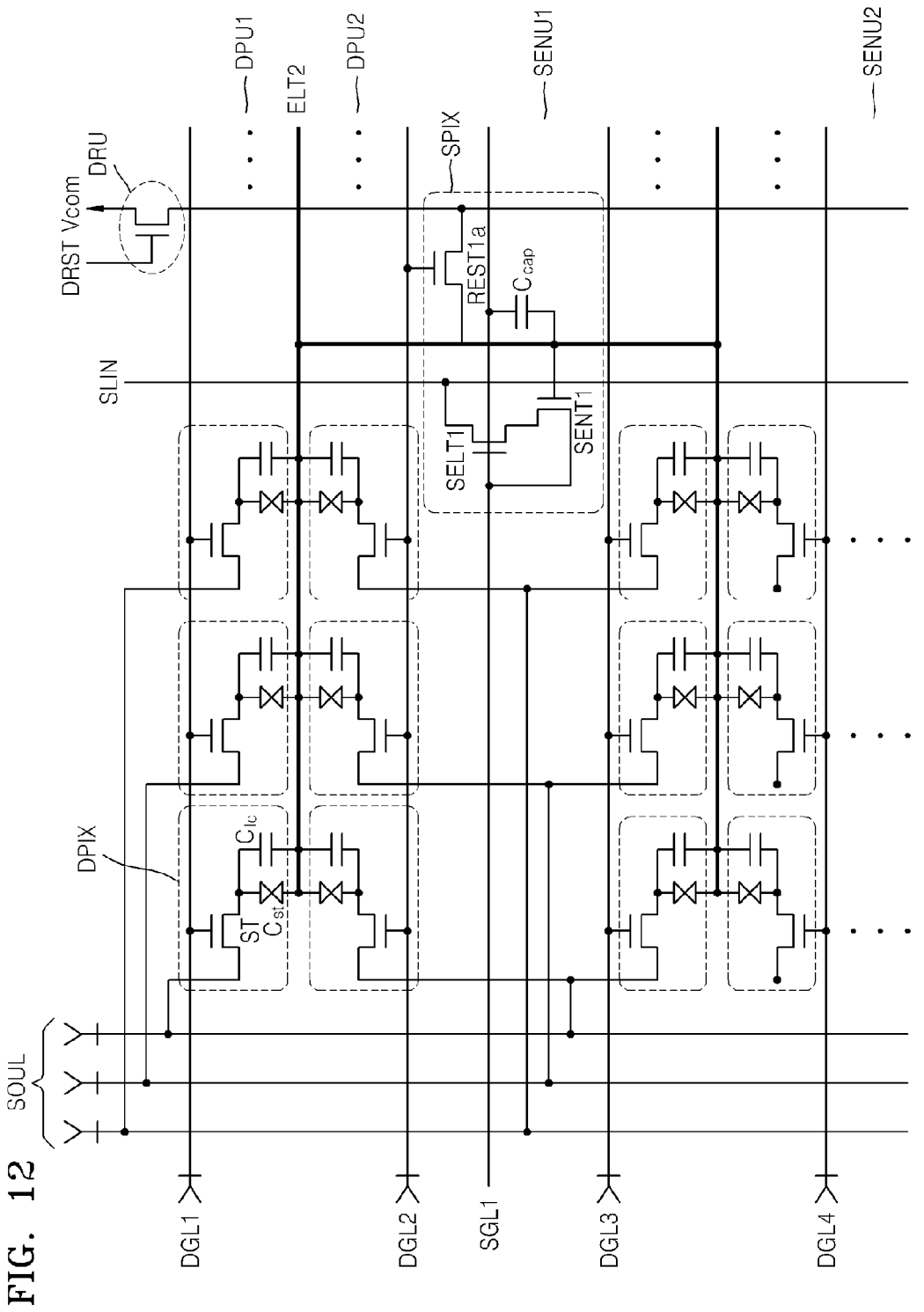

DPU1
ELT2
DPU2
SPIX
SENU1
SENU2
DRST
Vcom
DRU
SLIN
REST1a
Ccap
SELT1
SENT1
DPIX
Clc
ST
Cst
SOUL
DGL1
DGL2
SGL1
DGL3
DGL4

FIG. 12

FIG. 13

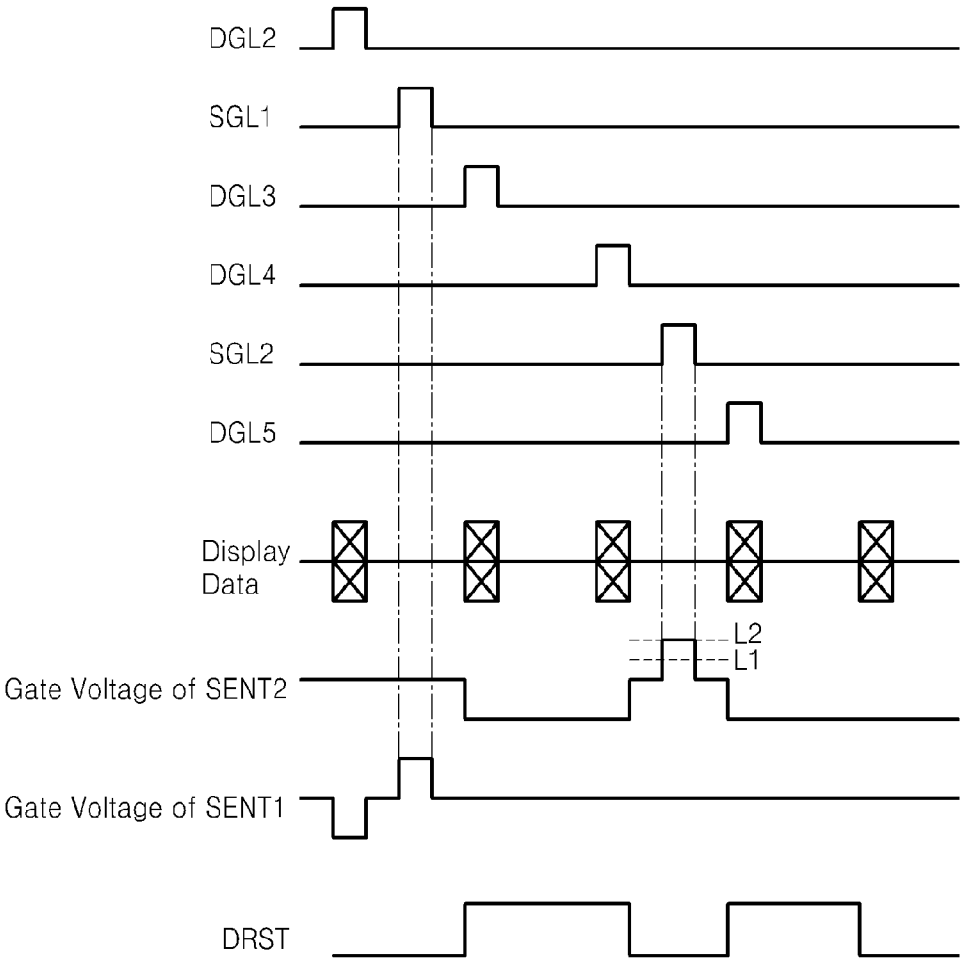

DGL2
SGL1
DGL3
DGL4
SGL2
DGL5
Display Data
L2
L1
Gate Voltage of SENT2
Gate Voltage of SENT1
DRST

FIG. 14A

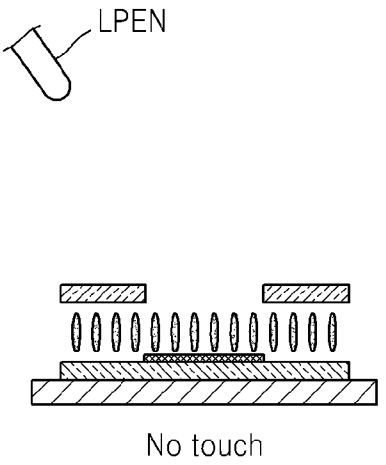


FIG. 14B

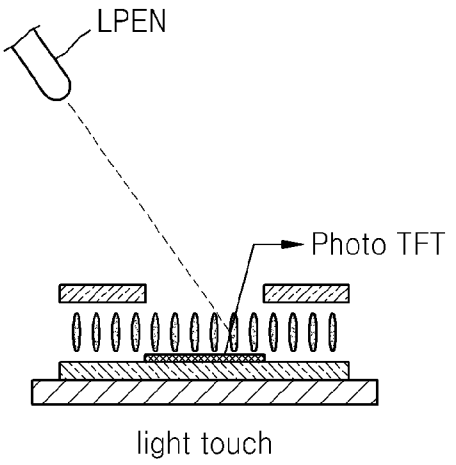


FIG. 15

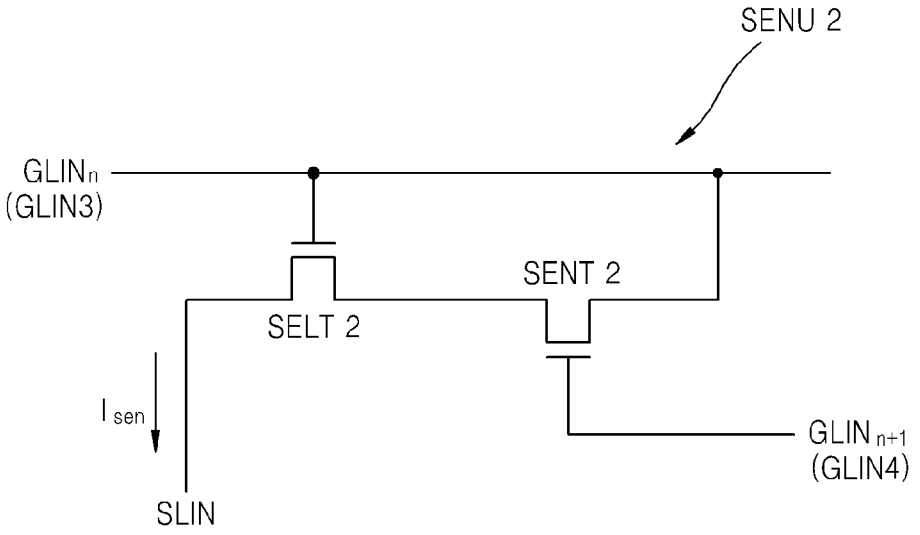

SENU 2
GLIN$_n$
(GLIN3)
SENT 2
SELT 2
I sen
GLIN $_{n+1}$
(GLIN4)
SLIN

FIG. 16

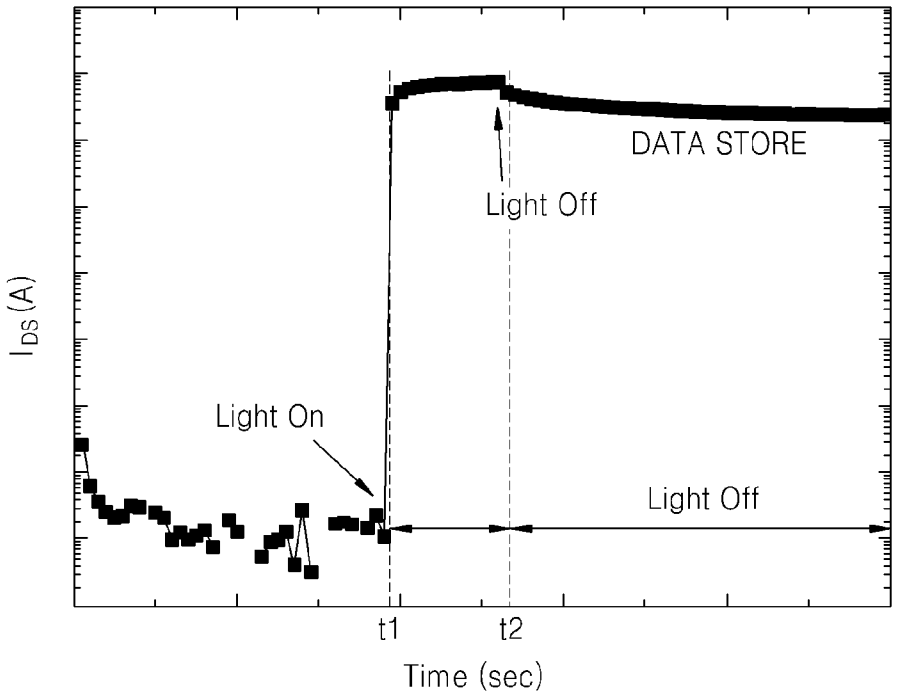

DATA STORE
Light Off
Light On
Light Off
I_{DS} (A)
t1
t2
Time (sec)

FIG. 17

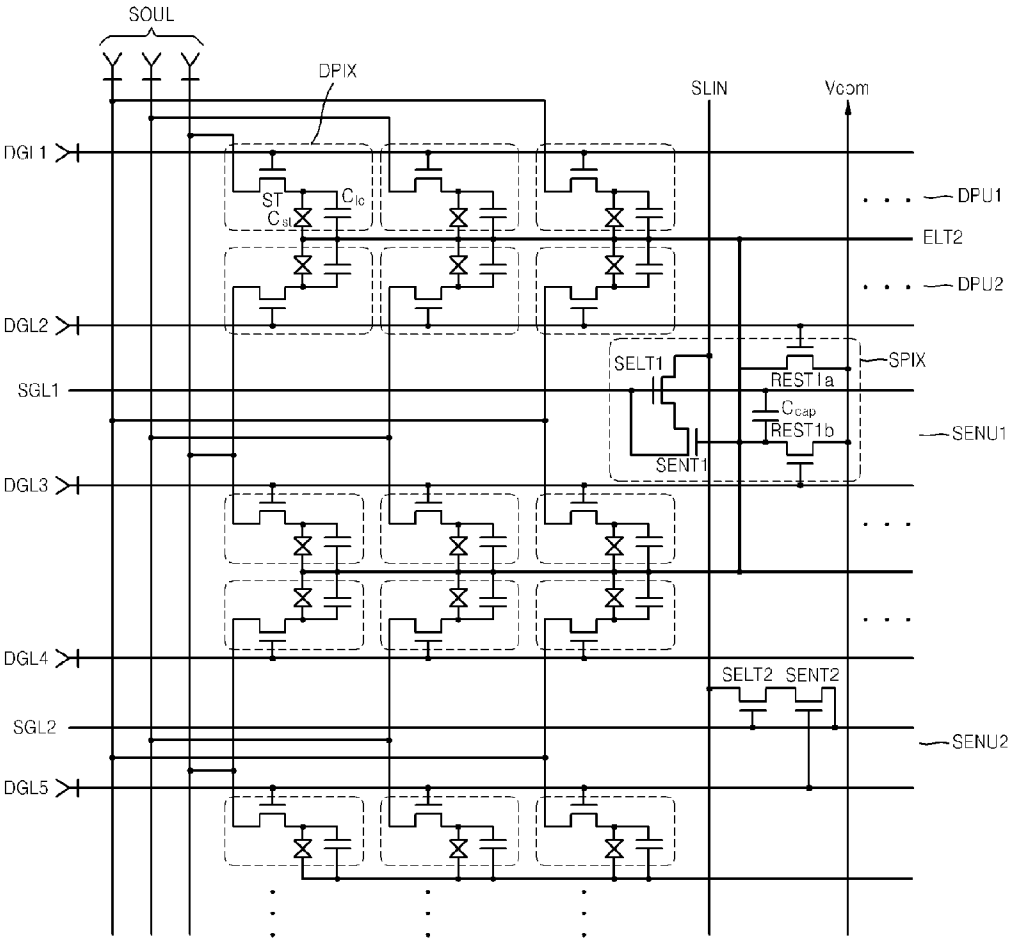

SOUL
DPIX
SLIN
Vcom
DGL1
DGL2
SGL1
DGL3
DGL4
SGL2
DGL5
ST
Clc
Cst
DPU1
ELT2
DPU2
SELT1
SENT1
REST1a
Ccap
REST1b
SPIX
SENU1
SELT2
SENT2
SENU2

FIG. 18A

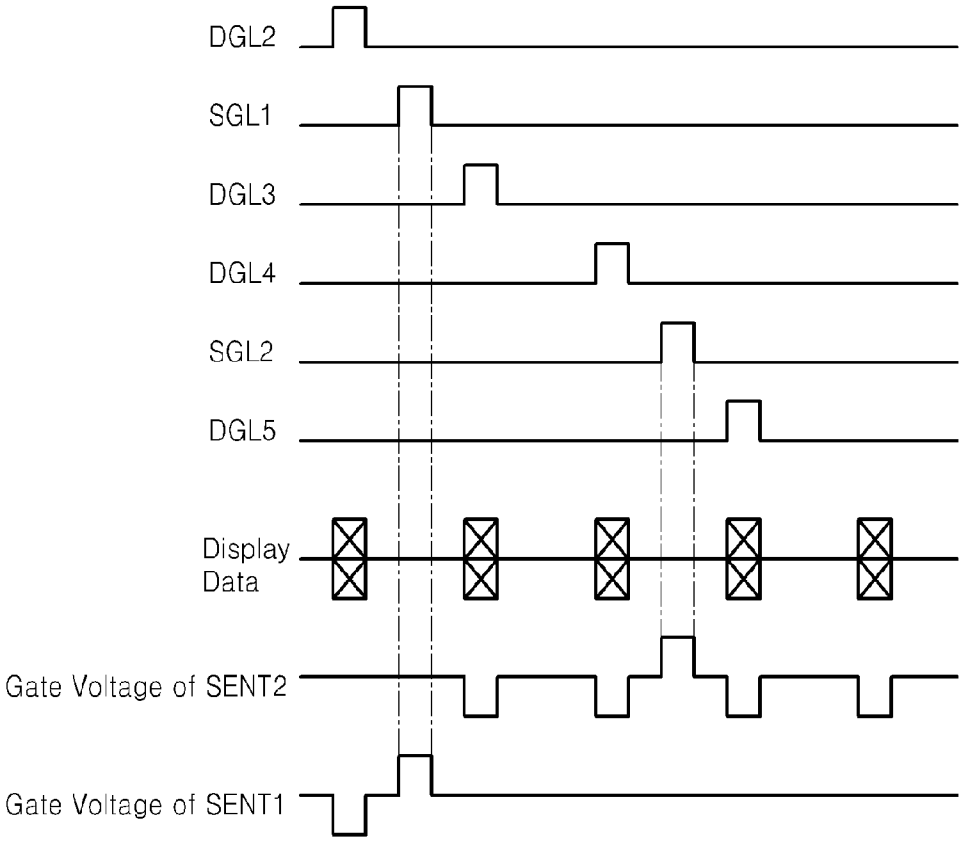

DGL2
SGL1
DGL3
DGL4
SGL2
DGL5
Display Data
Gate Voltage of SENT2
Gate Voltage of SENT1

FIG. 18B

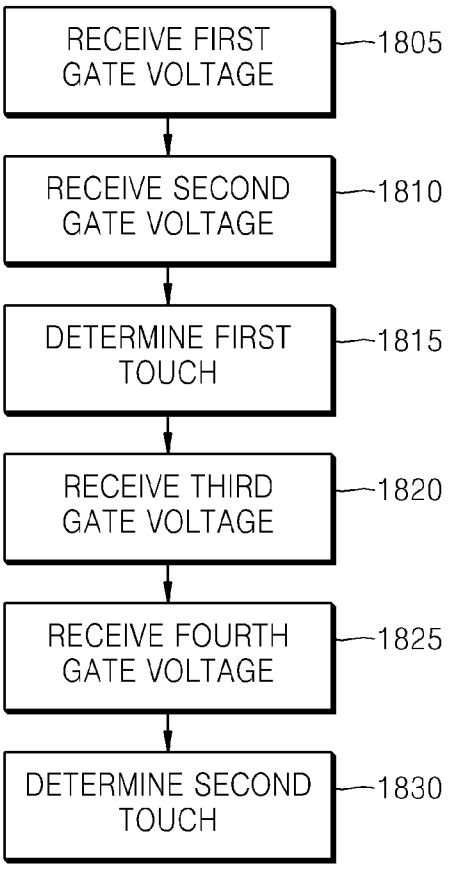

RECEIVE FIRST GATE VOLTAGE
1805
RECEIVE SECOND GATE VOLTAGE
1810
DETERMINE FIRST TOUCH
1815
RECEIVE THIRD GATE VOLTAGE
1820
RECEIVE FOURTH GATE VOLTAGE
1825
DETERMINE SECOND TOUCH
1830

FIG. 19

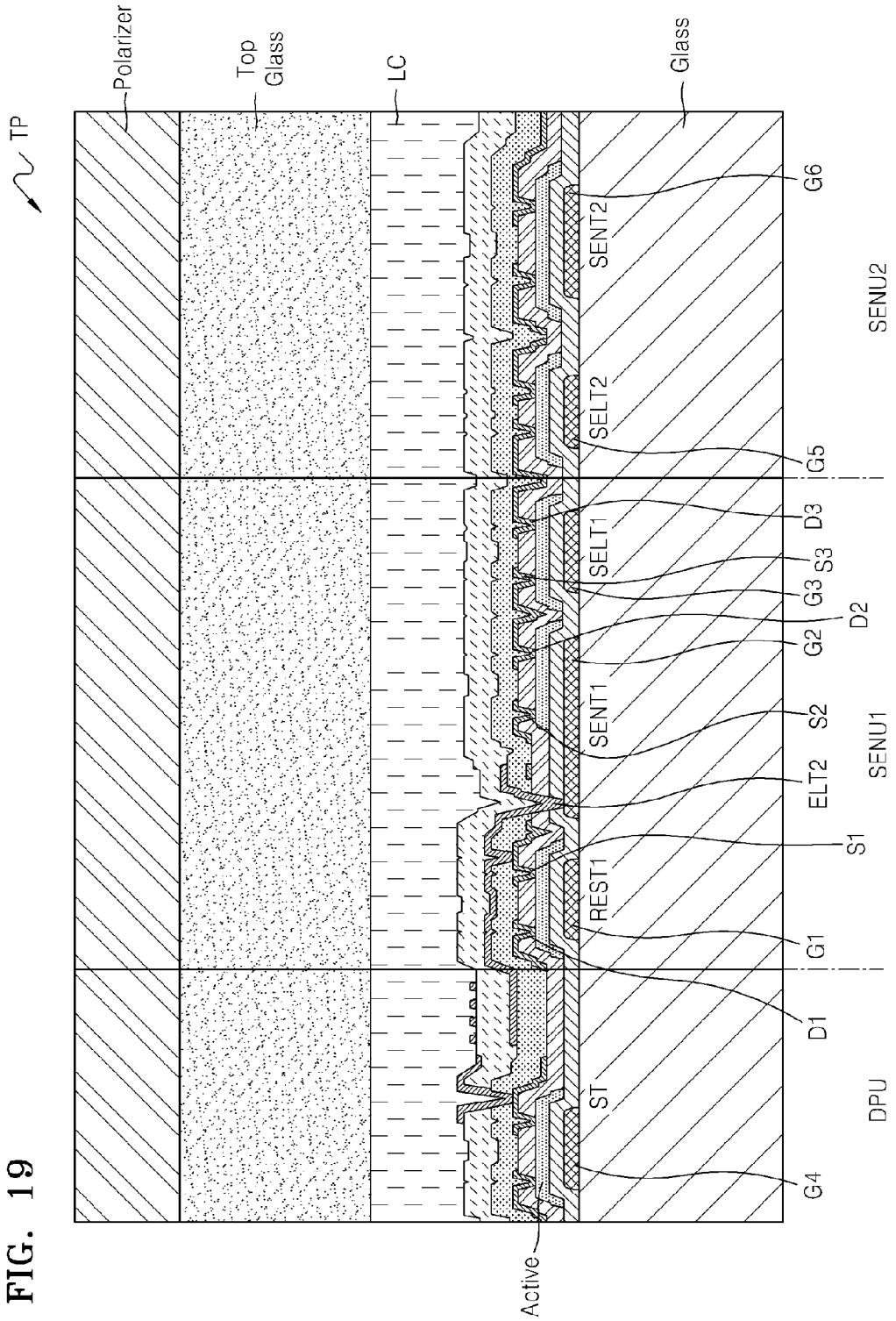

TP
Polarizer
Top Glass
LC
Glass
G6
SENT2
SELT2
G5
D3
SELT1
S3
G3
D2
G2
SENT1
S2
ELT2
S1
REST1
G1
D1
ST
G4
Active
SENU2
SENU1
DPU

FIG. 20

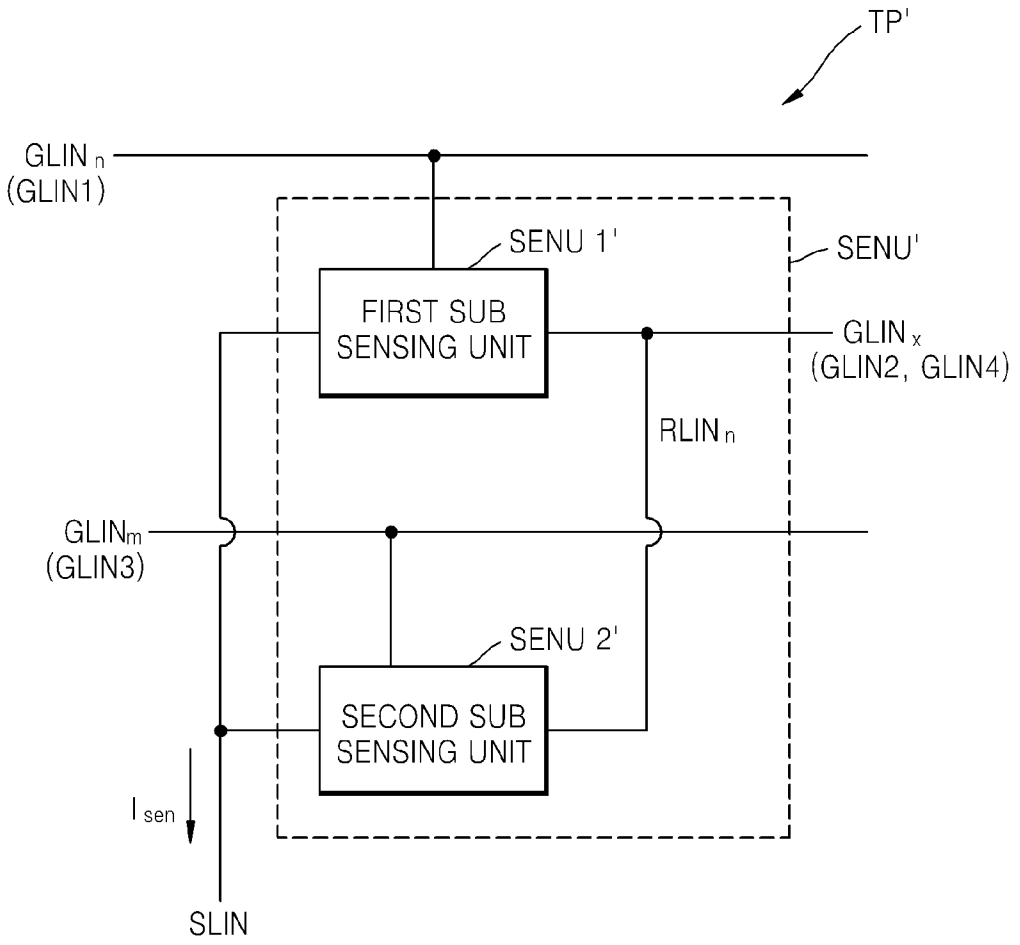

TP'
GLIN n
(GLIN1)
SENU 1'
SENU'
FIRST SUB
SENSING UNIT
GLIN x
(GLIN2, GLIN4)
RLIN n
GLINm
(GLIN3)
SENU 2'
SECOND SUB
SENSING UNIT
I sen
SLIN

FIG. 21A

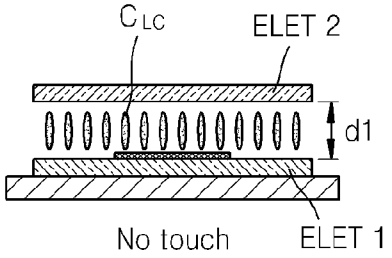


FIG. 21B

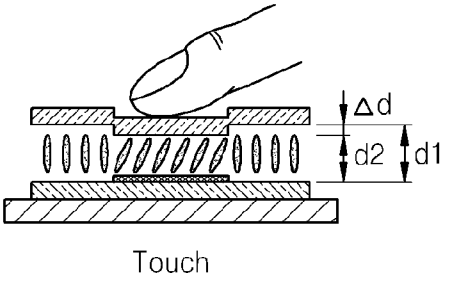


FIG. 22

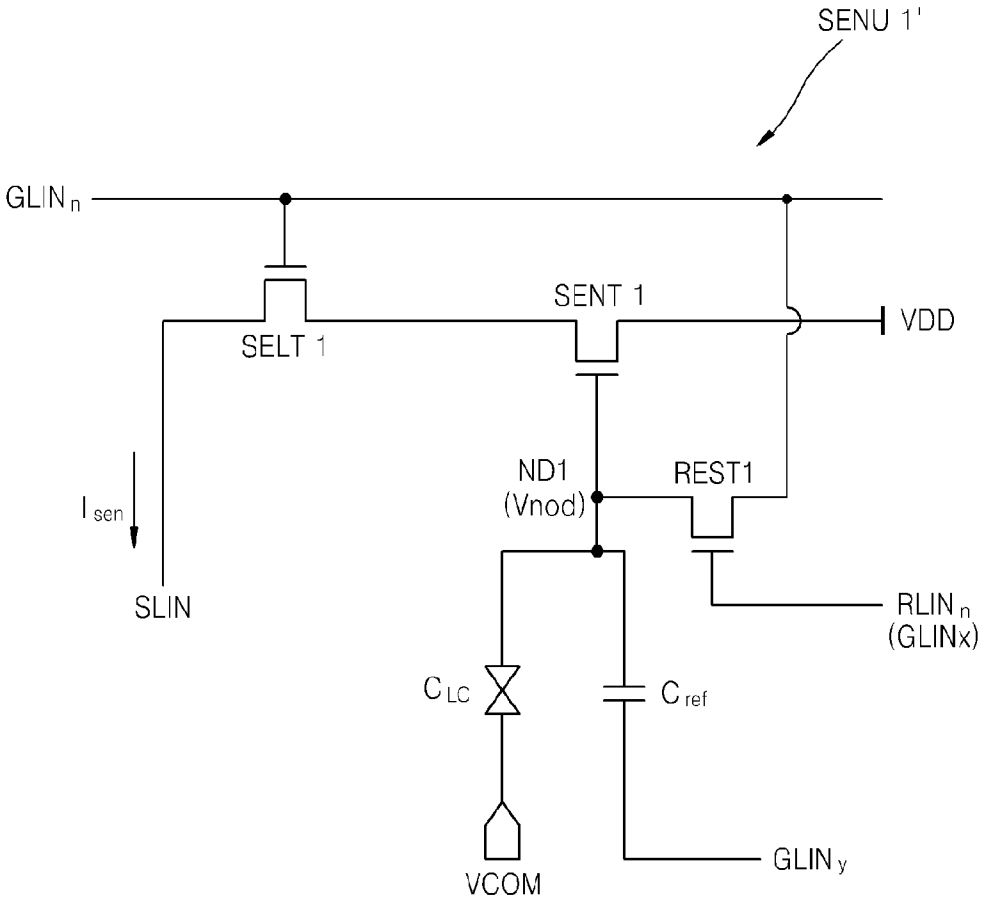


FIG. 23

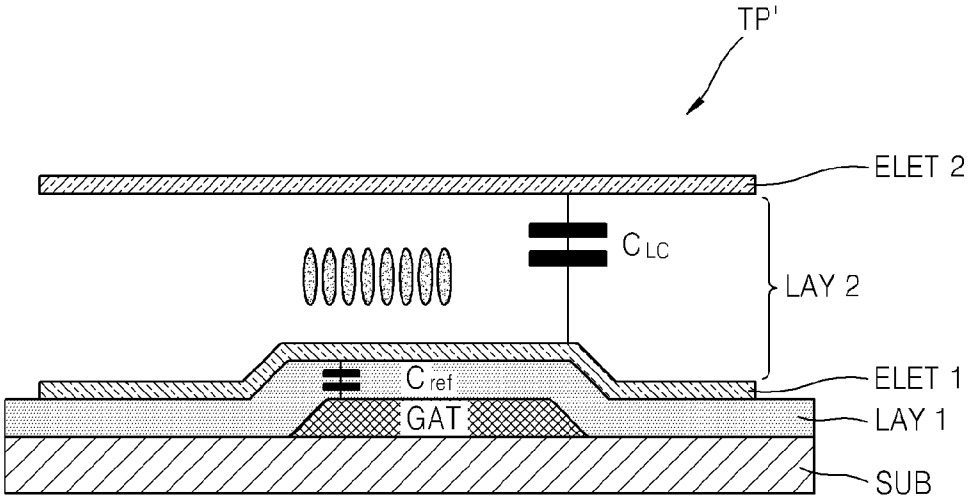

TP'
ELET 2
C LC
LAY 2
C ref
ELET 1
GAT
LAY 1
SUB

FIG. 24

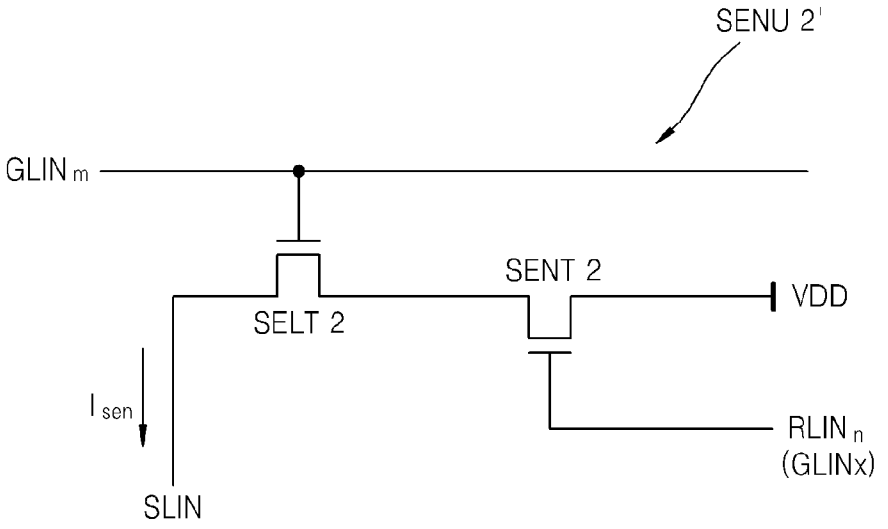

SENU 2'
GLIN m
SENT 2
VDD
SELT 2
I sen
RLIN n
(GLINx)
SLIN

FIG. 25

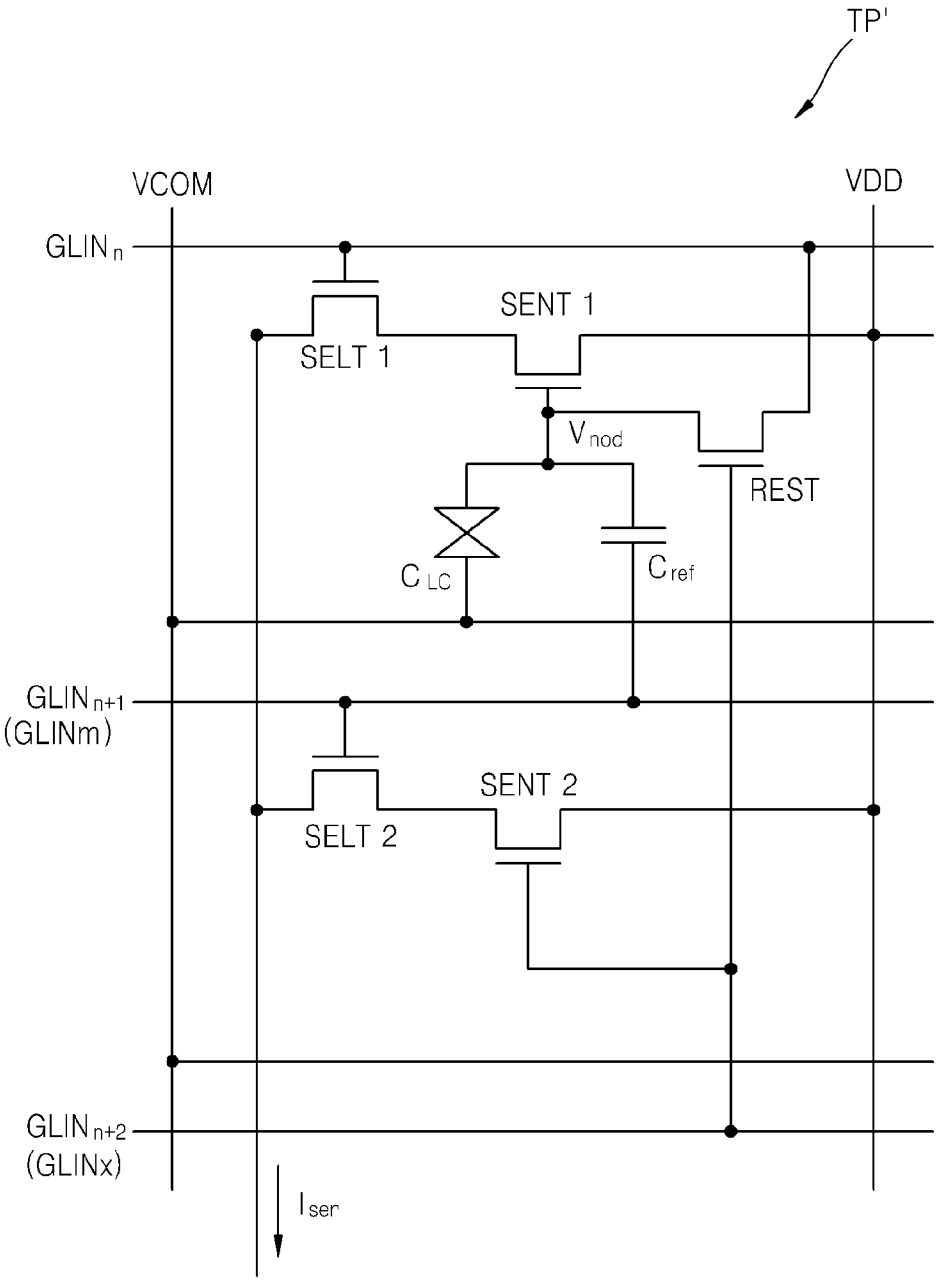

TP'
VCOM
VDD
GLIN n
SENT 1
SELT 1
V nod
REST
C LC
C ref
GLIN n+1
(GLINm)
SENT 2
SELT 2
GLIN n+2
(GLINx)
I ser

FIG. 26

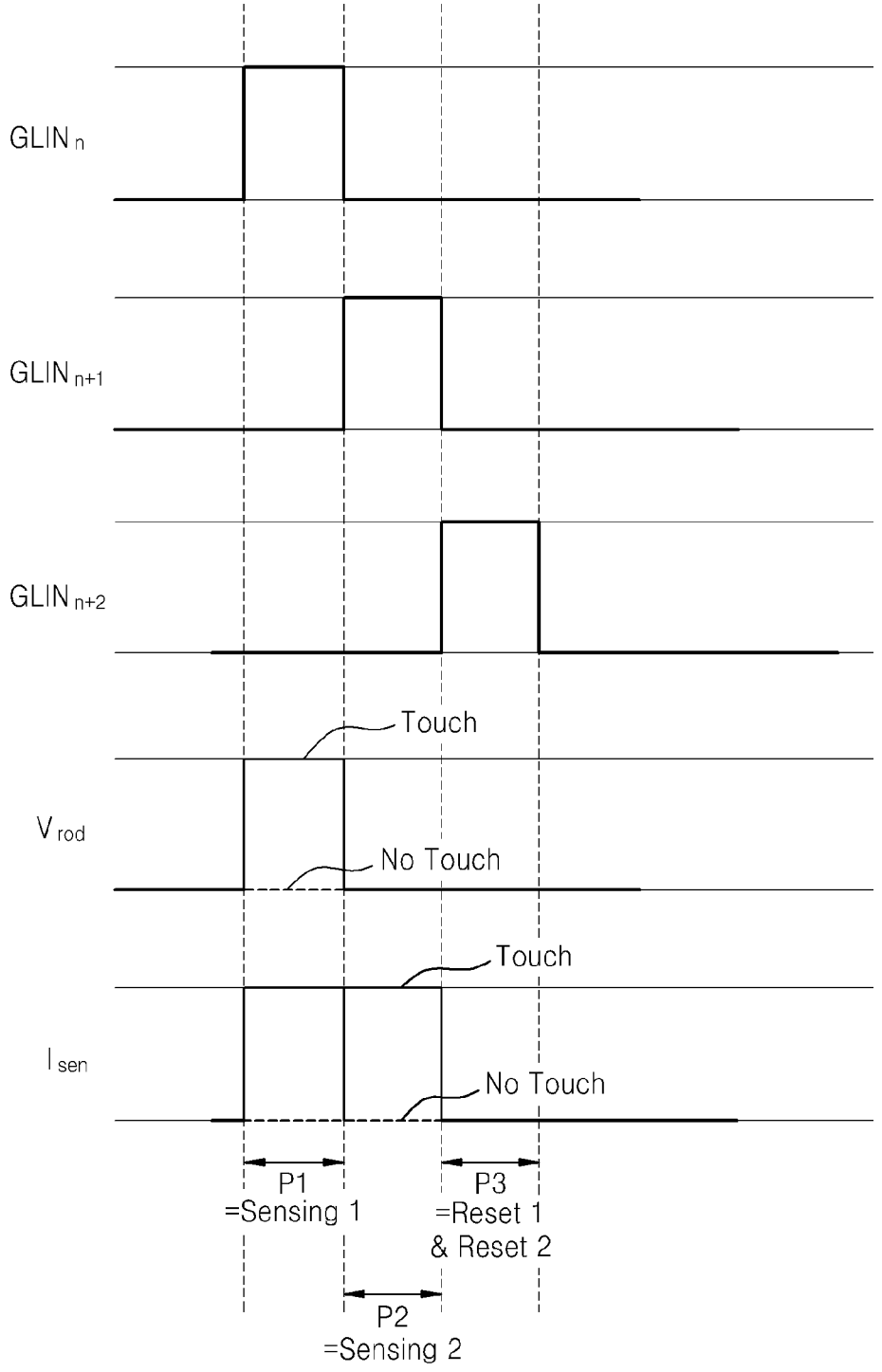

GLIN n
GLIN n+1
GLIN n+2
Touch
V rod
No Touch
Touch
I sen
No Touch
P1
=Sensing 1
P3
=Reset 1
& Reset 2
P2
=Sensing 2

FIG. 27

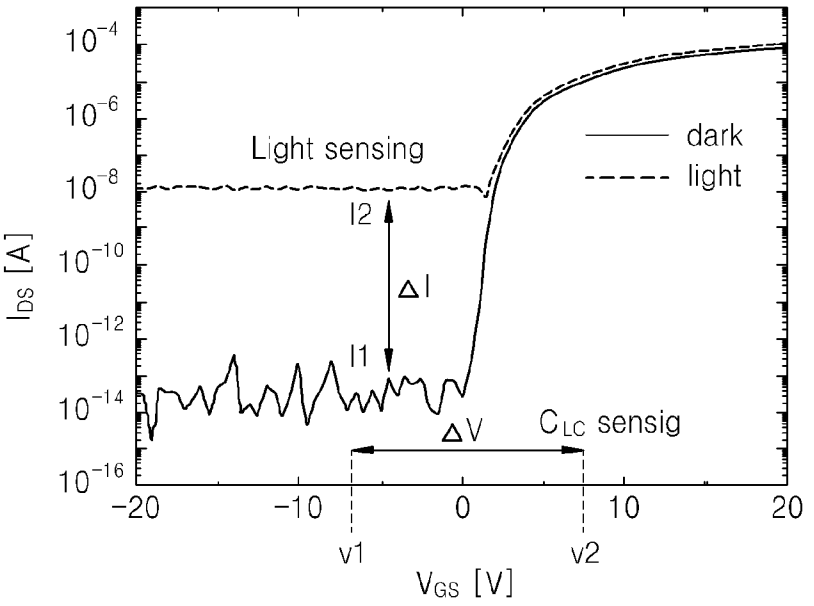

10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{-14}
10^{-16}
I_{DS} [A]
Light sensing
dark
light
I2
ΔI
I1
ΔV
C_{LC} sensig
−20
−10
0
10
20
v1
v2
V_{GS} [V]

FIG. 28

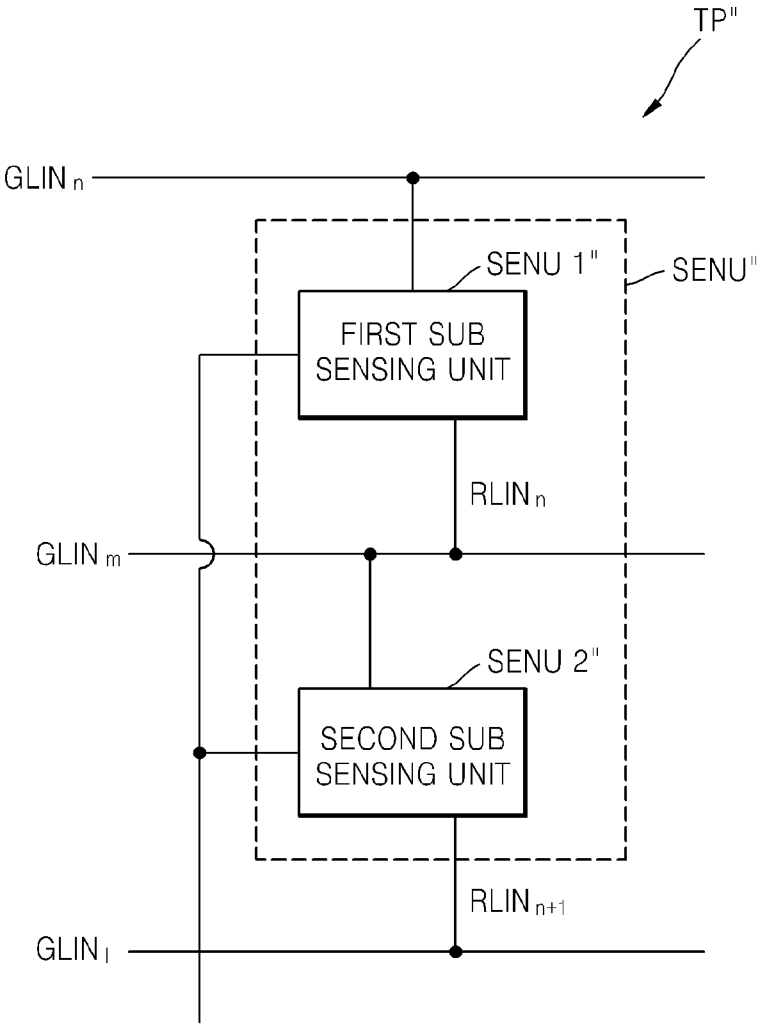

TP"
GLIN n
SENU 1"
SENU"
FIRST SUB SENSING UNIT
RLIN n
GLIN m
SENU 2"
SECOND SUB SENSING UNIT
RLIN n+1
GLIN l

FIG. 29

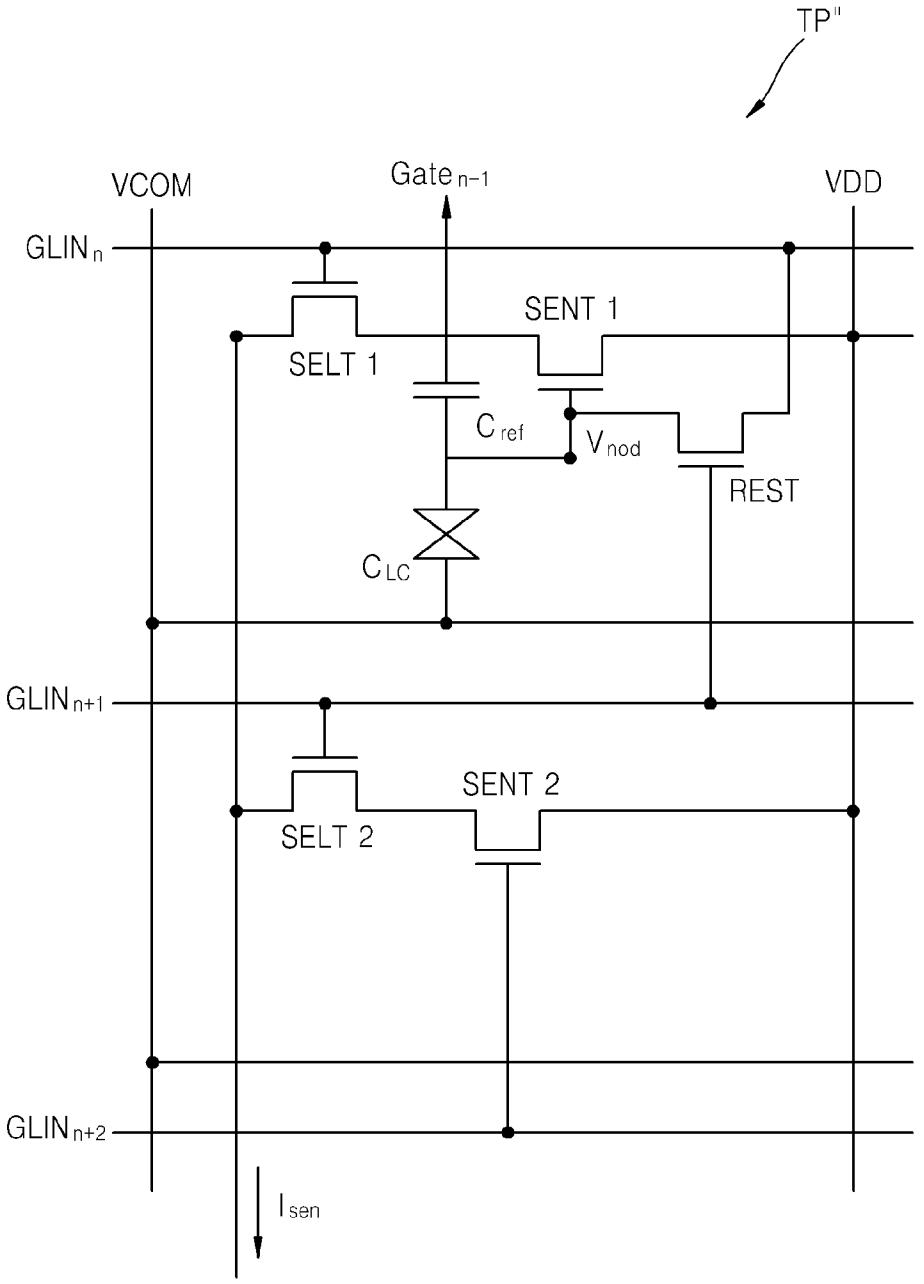

TP''
VCOM
Gate n-1
VDD
GLIN n
SELT 1
SENT 1
C ref
V nod
REST
C LC
GLIN n+1
SENT 2
SELT 2
GLIN n+2
I sen

FIG. 30

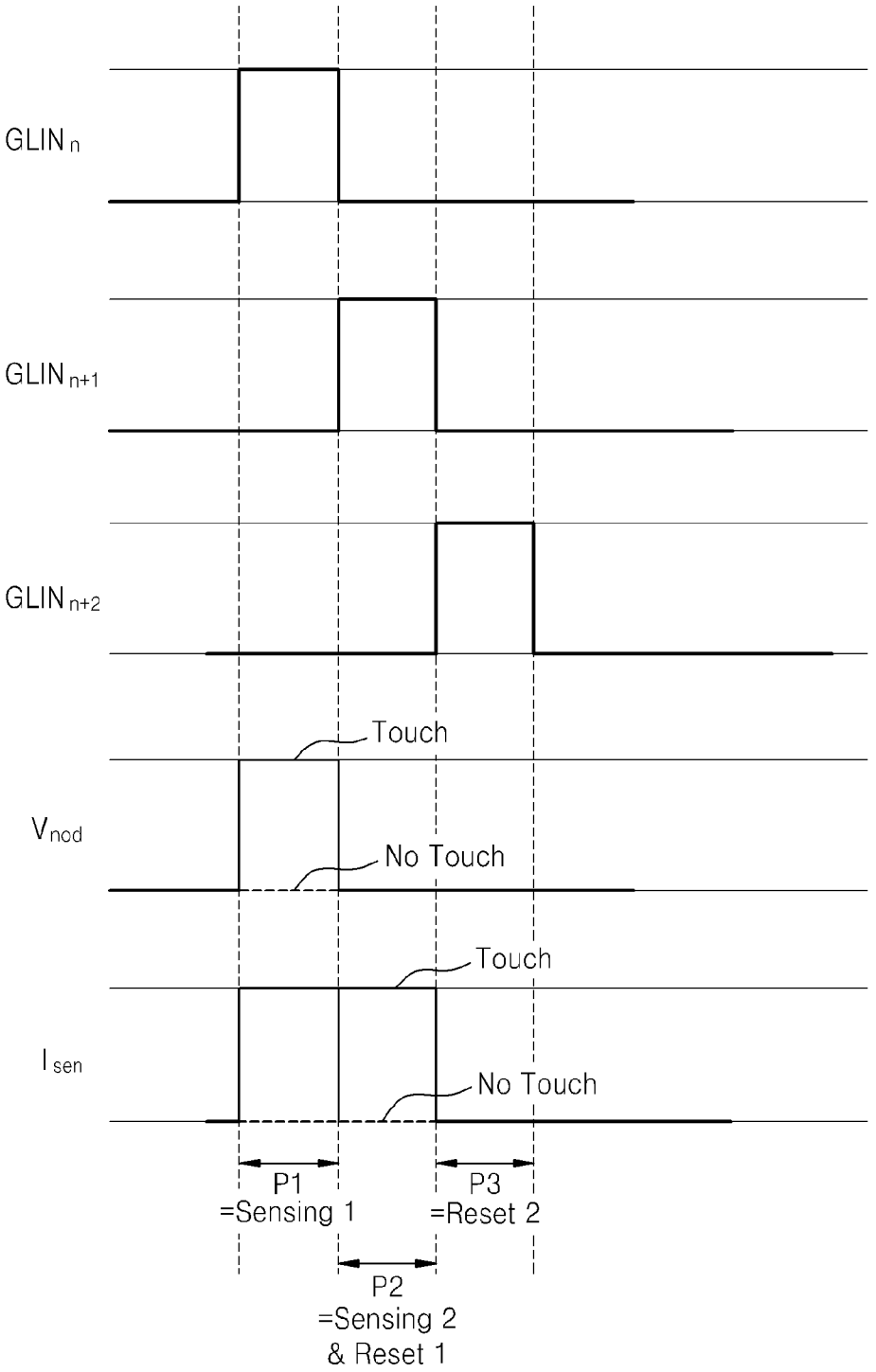

GLIN n
GLIN n+1
GLIN n+2
Touch
V nod
No Touch
Touch
I sen
No Touch
P1
=Sensing 1
P3
=Reset 2
P2
=Sensing 2
& Reset 1

FIG. 31

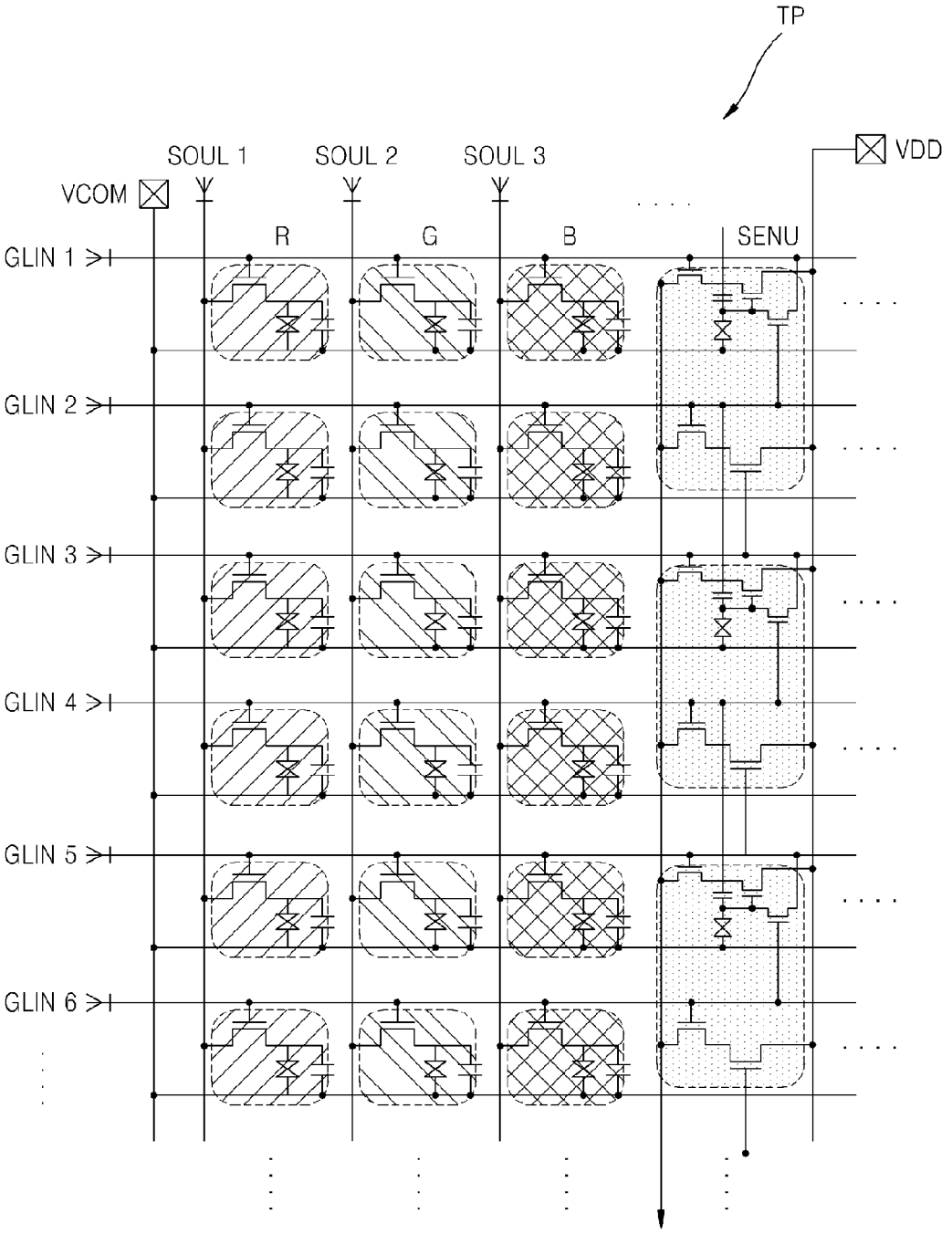

TP
SOUL 1
SOUL 2
SOUL 3
VDD
VCOM
R
G
B
SENU
GLIN 1
GLIN 2
GLIN 3
GLIN 4
GLIN 5
GLIN 6

FIG. 32

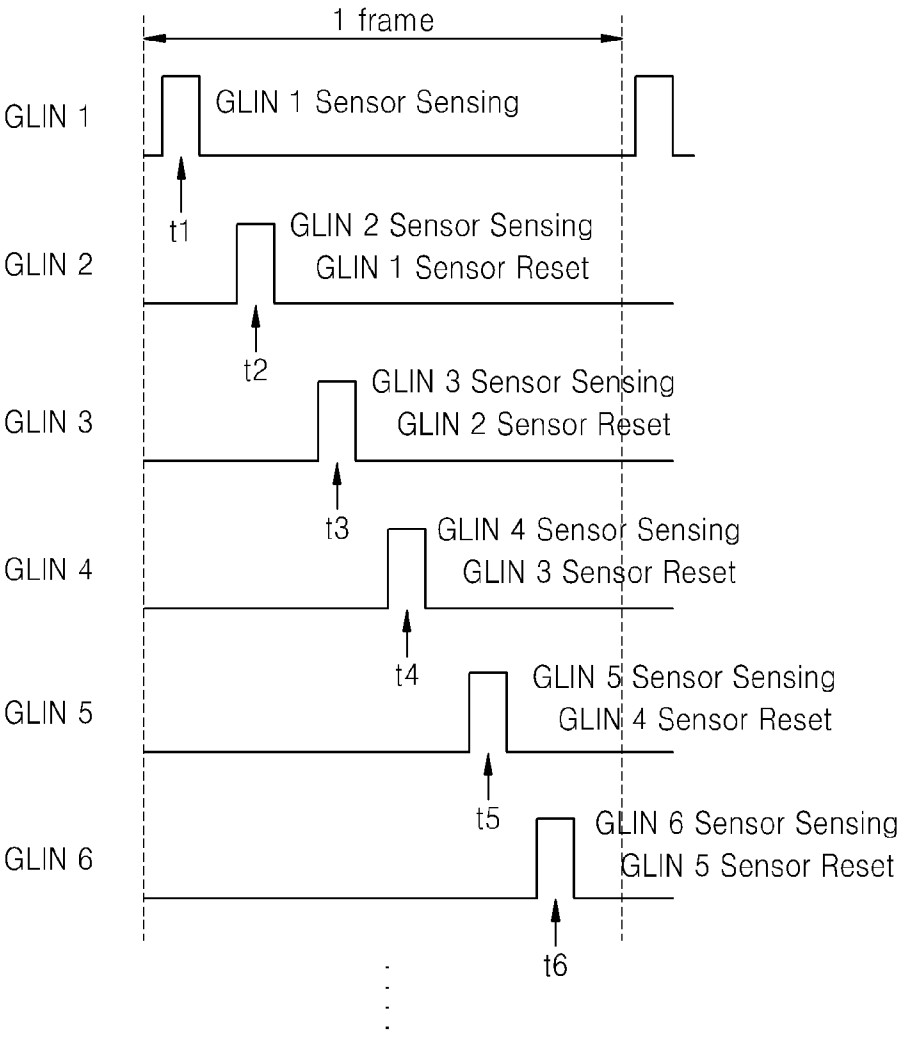

1 frame
GLIN 1
GLIN 1 Sensor Sensing
t1
GLIN 2
GLIN 2 Sensor Sensing
GLIN 1 Sensor Reset
t2
GLIN 3
GLIN 3 Sensor Sensing
GLIN 2 Sensor Reset
t3
GLIN 4
GLIN 4 Sensor Sensing
GLIN 3 Sensor Reset
t4
GLIN 5
GLIN 5 Sensor Sensing
GLIN 4 Sensor Reset
t5
GLIN 6
GLIN 6 Sensor Sensing
GLIN 5 Sensor Reset
t6

FIG. 33

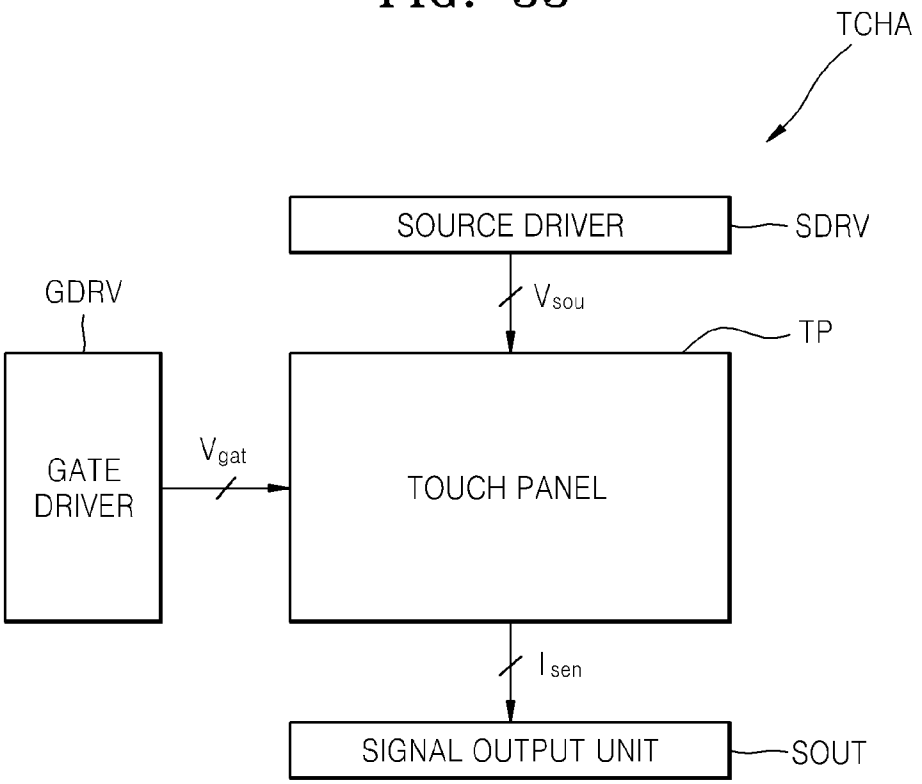
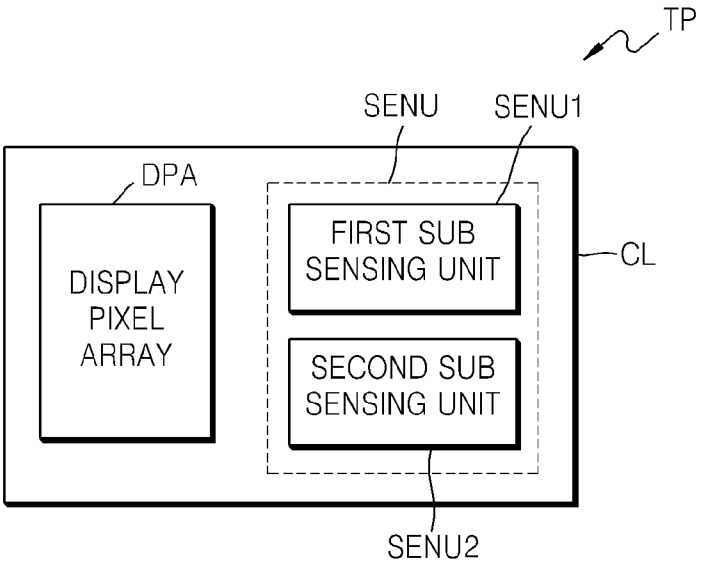

TCHA
SOURCE DRIVER
SDRV
GDRV
V_{sou}
TP
GATE DRIVER
V_{gat}
TOUCH PANEL
I_{sen}
SIGNAL OUTPUT UNIT
SOUT

FIG. 34


TP
SENU
SENU1
DPA
DISPLAY PIXEL ARRAY
FIRST SUB SENSING UNIT
SECOND SUB SENSING UNIT
CL
SENU2

HYBRID TOUCH PANEL, HYBRID TOUCH SCREEN APPARATUS, AND METHOD OF DRIVING THE HYBRID TOUCH PANEL

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2012-0108264, filed on Sep. 27, 2012, in the Korean Intellectual Property Office, the entire contents of which are incorporated herein in their entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] The example embodiments relates to a hybrid touch panel, a hybrid touch screen apparatus, and a method of driving the hybrid touch panel, and more particularly, to a hybrid touch screen apparatus having a structure adaptive to hybrid touch sensing and a method of adaptively driving the same.

[0004] 2. Description of the Related Art

[0005] Touch panels that may be driven according to various methods, e.g., a pressure-type resistive overlay method, a contact-type electrostatic capacitive method, a surface acoustic wave (SAW) method, and a piezoelectric method, have been developed and used. Furthermore, touch panels that employ an optical sensing method and that may thus be operated at a long distance may also have been developed and used.

SUMMARY

[0006] Provided are a hybrid touch panel having a structure adaptive to hybrid touch sensing, a hybrid touch screen apparatus, and a method of adaptively driving the hybrid touch panel. Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0007] According to an aspect of some example embodiments, a touch panel includes a sensing unit a first sub sensing unit configured to output a first sensing current in response to a voltage of a first gate line and configured to reset in response to a voltage of a second gate line, the first sensing current corresponding to a first touch type, and a second sub sensing unit configured to output a second sensing current in response to a voltage of a third gate line and configured to reset in response to a voltage of a fourth gate line, the second sensing current corresponding to a second touch type which is different than the first touch type, and a display unit configured to generate an image voltage corresponding to image data to be displayed, in response to at least one of the voltages of the first to fourth gate lines.

[0008] According to another aspect of at least one example embodiment, a touch screen apparatus includes a touch panel including a first sub sensing unit configured to output a first sensing current and a second sub sensing unit configured to output a second sensing current. The first sensing current corresponds to a first touch type. The second sensing current corresponds to a second touch type. The second touch type is different than the first touch type. The second sub sensing unit includes an oxide transistor configured to output the second sensing current.

[0009] According to an aspect of some example embodiments, a method of controlling a touch panel, the method comprising controlling first and second sensing units such that one of the first and second sensing units is active. The first sensing unit is configured to sense a first touch type of the touch panel. The second sensing unit is configured to sense a second touch type of the touch panel. The first touch type is different than the second touch types.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0011] FIG. **1** illustrates a touch panel according to an example embodiment;

[0012] FIGS. **2**A-**2**B are diagrams illustrating types of the touch panel of FIG. **1**;

[0013] FIGS. **3**A-**3**B are diagrams illustrating locations of a first electrode and a second electrode in the touch panel of FIG. **1**, according to example embodiments;

[0014] FIGS. **4**A-**4**B illustrate examples of touch panels, in which a first electrode and a second electrode are disposed differently from those of the touch panel of FIGS. **3**A-**3**B, according to example embodiments;

[0015] FIG. **5** is a block diagram illustrating some elements of the touch panel of FIG. **1**, according to an example embodiment;

[0016] FIG. **6** is a circuit diagram of a circuit equivalent to a first sub sensing unit of FIG. **5**;

[0017] FIG. **7** is a cross-sectional view of a first sub sensing unit shown in FIG. **6**;

[0018] FIGS. **8** and **9** illustrate a structure and operation of the touch panel of FIG. **5**, according to an example embodiment;

[0019] FIGS. **10** and **11** illustrate a structure and operation of the touch panel of FIG. **5**, according to another example embodiment;

[0020] FIGS. **12** and **13** illustrate a structure and operation of the touch panel of FIG. **5**, according to another example embodiment;

[0021] FIGS. **14**A-**14**B illustrate an object sensed by a second sub sensing unit of FIG. **1**,

[0022] FIG. **15** is a circuit diagram of a second sub sensing unit of FIG. **1** that performs a sensing operation illustrated in FIG. **14**, according to an example embodiment;

[0023] FIG. **16** is a graph showing features of the second sensing transistor of FIG. **15**, according to an example embodiment;

[0024] FIG. **17** is a circuit diagram illustrating in detail an example of the touch panel of FIG. **1**;

[0025] FIG. **18**A is a timing diagram illustrating an operation of the touch panel of FIG. **17**, according to another example embodiment;

[0026] FIG. **18**B illustrates a method of operating a touch panel according to an example embodiment;

[0027] FIG. **19** is a cross-sectional view of a part of the touch panel of FIG. **17**;

[0028] FIG. **20** illustrates another example of the touch panel having a sensing unit different from that of FIG. **1**;

[0029] FIGS. **21**A-**21**B illustrate an object sensed by a first sub sensing unit of FIG. **20**;

[0030] FIG. **22** is a circuit diagram illustrating an example of the first sub sensing unit of FIG. **20** that performs a sensing operation as illustrated in FIGS. **21**A-**21**B;

[0031] FIG. **23** is a diagram illustrating a concept of a cell capacitance illustrated in FIG. **22**;

[0032] FIG. **24** is a circuit diagram of an example of a second sub sensing unit of FIG. **20**;

[0033] FIG. **25** is a circuit diagram illustrating in detail an example of the touch panel of FIG. **20** including the first sub sensing unit of FIG. **22** and the second sub sensing unit of FIG. **24**;

[0034] FIG. **26** is a timing diagram illustrating operations of the first and second sub sensing units of FIG. **25**, according to another example embodiment;

[0035] FIG. **27** is a graph showing a sensing operation of the touch panel of FIG. **20** according to another example embodiment;

[0036] FIG. **28** is a circuit diagram of another example of the touch panel having a sensing unit different from that of FIG. **1**;

[0037] FIGS. **29** and **30** illustrate a structure and operation of the touch panel of FIG. **28**, according to another example embodiment;

[0038] FIG. **31** is a circuit diagram of another example of the touch panel of FIG. **1**;

[0039] FIG. **32** is a timing diagram illustrating an operation of the touch panel of FIG. **31** according to another example embodiment;

[0040] FIG. **33** is a block diagram of a touch screen apparatus according to an example embodiment; and

[0041] FIG. **34** is a block diagram of a touch panel according to another example embodiment.

DETAILED DESCRIPTION

[0042] Example embodiments will now be described more fully with reference to the accompanying drawings, in which some example embodiments are shown. Example embodiments, may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these example embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of example embodiments of inventive concepts to those of ordinary skill in the art. In the drawings, the thicknesses of layers and regions are exaggerated for clarity. Like reference numerals in the drawings denote like elements, and thus their description may be omitted.

[0043] It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present. As used herein the term "and/or" includes any and all combinations of one or more of the associated listed items. Other words used to describe the relationship between elements or layers should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," "on" versus "directly on").

[0044] It will be understood that, although the terms "first", "second", etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of example embodiments.

[0045] Spatially relative terms, such as "beneath," "below," "lower," "above," "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0046] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "includes" and/or "including," if used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0047] Example embodiments are described herein with reference to cross-sectional illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of example embodiments. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, example embodiments should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of example embodiments.

[0048] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It will be further understood that terms, such as those defined in commonly-used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0049] FIG. **1** is a diagram illustrating a touch panel TP according to an example embodiment. Referring to FIG. **1**, the touch panel TP includes a sensing unit SENU and a display unit DPU. The sensing unit SENU includes a first sub sensing unit SENU**1** and a second sub sensing unit SENU**2**. The first sub sensing unit SENU**1** outputs sensing current I_{sen} corresponding to a first touch variation TVAL**1** via a sensing line SLIN (shown in FIG. **6**), in response to activation of a first

gate line GLIN1. The first sub sensing unit SENU1 is reset when the first gate line GLIN1 is deactivated and a second gate line GLIN2 is activated. The second sub sensing unit SENU2 outputs sensing current I_{sen} corresponding to a second touch variation TVAL2 via the sensing line SLIN, in response to activation of a third gate line GLIN3. The second sub sensing unit SENU2 is reset when the third gate line GLIN3 is deactivated and a fourth gate line GLIN4 is activated.

[0050] In FIG. 1, the first gate line GLIN1 and the third gate line GLIN3 may be sensor gate lines activated during a sensing operation, and the second gate line GLIN2 and the fourth gate line GLIN4 may be display gate lines activated during a display operation. In other words, in the touch panel TP, the display gate lines may be used to reset the sensing unit SENU.

[0051] The type of the second touch variation TVAL2 is different from that of the first touch variation TVAL1. For example, the first touch variation TVAL1 may indicate whether the touch panel TP is physically touched, and the second touch variation TVAL2 may indicate whether the touch panel TP is optical touched, as will be described in detail below. Unless specified otherwise, it is hereinafter assumed that the first sub sensing unit SENU1 senses physical touch and the second sub sensing unit SENU2 senses optical touch.

[0052] Referring to FIG. 1, the display unit DPU generates an image voltage Vimg corresponding to image data IDTA that is to be displayed, in response to activation of a corresponding gate line among the first gate line GLIN1 to the fourth gate line GLIN4. The first gate line GLIN1 to the fourth gate line GLIN4 may be different types of gate lines, or some of the first gate line GLIN1 to the fourth gate line GLIN4 may be the same gate line. The first gate line GLIN1 to the fourth gate line GLIN4 may be disposed adjacent to or apart from one another, and may each include a plurality of lines, as will be described in detail below. A gate driver **100** generates signals across the first gate GLIN1 to the fourth gate GLIN4.

[0053] FIGS. 2A-2B are diagrams illustrating types of the touch panel TP of FIG. 1. Referring to FIGS. 1 and 2A, in a touch panel TP, the display unit DPU (cell) and the sensing unit SENU that senses touch (touch function) illustrated in FIG. 1 may be disposed on the same layer CL between glasses GL1 and GL2, between polarizers PL1 and PL2. Such a touch panel in which a pixel for displaying and a circuit for sensing are disposed on the same layer (array) may be referred to as an in-cell type. The touch panel TP which is an in-cell type as illustrated in FIG. 2A may be manufactured while reducing manufacture costs, simplifying a manufacture process, and reducing the thickness of a panel, compared to a touch panel TP of FIG. 2B in which a touch pad (sensing unit SENU) is disposed separately from display pixels (display unit DPU). The touch panel TP may be driven according to a plane line switching (PLS) mode that guarantees wide viewing angle, but example embodiments are not limited thereto and the touch panel TP may be embodied as an in-plane switching (IPS) panel or the like.

[0054] FIG. 2B illustrates a case where a touch pad TL that performs a touch function is disposed between an upper polarizer PL1 and an upper glass GL1. A panel as illustrated in FIG. 2B may be referred to as an on-cell type.

[0055] When a touch panel is an in-cell type in which a display unit and a sensing unit are disposed on the same layer, an aperture ratio may be reduced due to the sensing unit. To minimize a reduction in the aperture ratio, a first electrode and a second electrode may be arranged as illustrated in FIGS. 3A-3B.

[0056] FIGS. 3A-3B are diagrams illustrating locations of a first electrode ELT 1 and a second electrode ELT2 in the touch panel TP of FIG. 1, according to example embodiments.

[0057] Referring to FIGS. 1 and 3A, in the touch panel TP, both a first electrode ELT1 and a second electrode ELT2 may be formed at a first side of a liquid crystal LC. The first electrode ELT1 may be a pixel electrode, and a second electrode ELT2 may be a common electrode.

[0058] As will be described below, each of pixels included in the display unit DPU may include a transistor that is turned on to apply an image voltage Vimg to the first electrode ELT1, in response to activation of a display gate line DGL. The image voltage Vimg is a voltage that corresponds to the image data IDTA to be displayed and that is applied to a source line connected to one terminal of the transistor. A common voltage (reference voltage) may be applied to the second electrode ELT2. A twisting degree of the liquid crystal LC varies according to the difference between voltages of the first electrode ELT1 and the second electrode ELT2, and the transmittance of backlight varies according to the twisting degree of the liquid crystal LC, thereby displaying the image data IDTA.

[0059] As illustrated in FIG. 3B, in the touch panel TP, the second electrode ELT2 may be used as a sensing electrode SELT that senses whether touch is made, as will be described in detail below. In FIGS. 3A and 3B, both the first electrode ELT1 and the second electrode ELT2 are formed at the first side of the liquid crystal LC, whereas in a touch panel of FIG. 4A, a first electrode ELT1 is disposed at a first side of a liquid crystal LC and a second electrode ELT2 is disposed at a second side of a liquid crystal LC. In this case, as illustrated in FIG. 4B, an aperture ratio may be reduced, since the area of a sensing electrode SELT should be increased due to an interference effect occurring among the first electrode ELT1, the second electrode ELT2, and the sensing electrode SELT.

[0060] The touch panel TP may have the first electrode ELT1 and the second electrode ELT2 in a structure as illustrated in FIGS. 3A and 3B, thereby preventing a reduction in the aperture ratio. A structure and operation of a sensing unit that performs sensing, included in a touch panel in which a first electrode ELT1 and a second electrode ELT2 are included in the structure as illustrated in FIGS. 3A and 3B and the second electrode ELT2 is used as a sensing electrode SELT that senses whether touch is made, will now be described.

[0061] FIG. 5 is a block diagram illustrating some elements of the touch panel TP of FIG. 1, according to an example embodiment. Referring to FIGS. 1 and 5, the first sub sensing unit SENU1 according to an example embodiment, senses whether a finger capacitance Cfig occurs due to physical touching of the touch panel TP based on a voltage variation Vvar in a second electrode ELT2 in response to activation of a sensor gate line SGL. As described above, the second electrode ELT2 may be a common electrode.

[0062] The display unit DPU applies an image voltage Vimg to the first electrode ELT1, in response to the display gate line DGL. A liquid crystal may be driven according to a voltage difference Vdiff between the first electrode ELT1 and the second electrode ELT2. Electric charges corresponding to the voltage difference Vdiff between the first electrode ELT1 and the second electrode ELT2 are charged in a storage capac-

ity of the display unit DPU, which is described in detail below. In FIG. **5**, the display gate line DGL may be the same as the second gate line GLIN**2** or the fourth gate line GLIN**4** illustrated in FIG. **1**.

[0063] As described above, the first sub sensing unit SENU**1** senses whether a finger capacitance Cfig occurs due to physical touching of the touch panel TP, based on a voltage variation Vvar at the second electrode ELT**2**, in response to activation of the sensor gate line SGL. The finger capacitance Cfig is a parasitic capacitance formed due to a voltage difference between a finger as an electric capacitor and the second electrode ELT**2**, caused by physical touch.

[0064] The sensor gate line SGL of FIG. **5** may be the same as the first gate line GLIN**1** of FIG. **1**. The touch panel TP of FIG. **5** includes the second sub sensing unit SENU**2**, similar to the touch panel TP of FIG. **1**. Thus, the touch panel TP of FIG. **5** may sense not only physical touch but also another touch, e.g., optical touch. However, for convenience of explanation, only the first sub sensing unit SENU**1** that senses physical touch is illustrated in FIG. **5**.

[0065] A value sensed by the first sub sensing unit SENU**1** is output as sensing current I_{sen} via the sensing line SLIN. A structure and operation of the first sub sensing unit SENU**1** of FIG. **5** will now be described in more detail.

[0066] FIG. **6** is a circuit diagram of a circuit equivalent to the first sub sensing unit SENU**1** of FIG. **5**. Referring to FIGS. **5** and **6**, the first sub sensing unit SENU**1** according to an example embodiment may include a first sensing transistor SENT**1**, a first selection transistor SELT**1**, and a first reset transistor REST**1**. A gate and one terminal of the first sensing transistor SENT**1** are connected to the second electrode ELT**2** and one terminal of the first selection transistor SELT**1**, respectively. A gate, one terminal, and the other terminal of the first selection transistor SELT**1** are connected to a gate line $GLIN_n$, one terminal of the sensing transistor SENT**1**, and a sensing line SLIN, respectively. A gate, one terminal, and the other terminal of the first reset transistor REST**1** are connected to a gate line $GLIN_{n+1}$, the second electrode ELT**2**, and the gate line $GLIN_n$, respectively.

[0067] As described above, the second electrode ELT**2** may be a common electrode. The gate line $GLIN_n$ may be the same as the sensor gate line SGL of FIG. **5**, and the gate line $GLIN_{n+1}$ may be the same as the display gate line DGL of FIG. **5**. Thus, the first selection transistor SELT**1** is gated in response to activation of the sensor gate line SGL, and supplies sensing current I_{sen}, which corresponds to a voltage variation Vvar at the second electrode ELT**2**, sensed by the first sensing transistor SENT**1** to the sensing line SLIN.

[0068] The voltage variation Vvar at the second electrode ELT**2** may be based on a ratio of a finger capacitance Cfig and a coupling capacitance Ccap between the second electrode ELT**2** and the sensor gate line SGL. For example, if the finger capacitance Cfig is not formed, i.e., if touch is not made, then a voltage of the second electrode ELT**2** may be equal to a voltage applied to the sensor gate line SGL. However, if the finger capacitance Cfig is formed, for example, if the finger capacitance Cfig and the coupling capacitance Ccap are the same, then the voltage of the second electrode ELT**2** may be half the voltage applied to the sensor gate line SGL. When the first sensing transistor SENT**1** is turned on, the first sensing transistor SENT**1** may generate the sensing current I_{sen} to correspond to the ratio of the finger capacitance Cfig and the coupling capacitance Ccap.

[0069] After touch is sensed in response to activation of the sensor gate line SGL as described above, the second electrode ELT**2** is reset in response to deactivation of the sensor gate line SGL and activation of the display gate line DGL. For example, the first reset transistor REST**1** may reset the second electrode ELT**2** by a common voltage.

[0070] Referring to FIGS. **5** and **6**, both the other terminal of the first sensing transistor SENT**1** and the other terminal of the first reset transistor REST**1** may be connected to the sensor gate line SGL. By sharing the other terminal of the first sensing transistor SENT**1** with another transistor, a parasitic capacitance that may be generated due to a variation in the finger capacitance Cfig may be reduced.

[0071] FIG. **7** is a cross-sectional view of a sub-sensing unit SENU**1**, such as shown in FIG. **6**. Referring to FIGS. **6** and **7**, a gate G**1** of a first reset transistor REST**1**, a gate G**2** of a first sensing transistor SENT**1**, and a gate G**3** of a first selection transistor SELT**1**, are formed on a glass substrate and active areas Active that are insulated from the gates G**1**, G**2**, and G**3** via insulators are respectively formed on the insulators. The active areas Active may be electrically connected to source and drain electrodes S**1** and D**1**, S**2** and D**2**, and S**3** and D**3**. One terminal S**1** of the first reset transistor REST**1** is connected to a second electrode ELT**2**. A gate G**2** and one terminal D**2** of the first sensing transistor SENT**1** are connected to the second electrode ELT**2** and one terminal S**3** of the first selection transistor SELT**1**, respectively. The gate G**1** and the other terminal D**1** of the first reset transistor REST**1**, the other terminal S**1** of the first sensing transistor SENT**1**, and the gate G**3** and the other terminal D**3** of the first selection transistor SELT**1** may be connected to the gate line GLINn, the GLINn+1, or the sensing line SLIN of FIG. **6**, via contacts (not shown).

[0072] As described above, a coupling capacitance Ccap is formed by the second electrode ELT**2** and the source and drain electrodes S**1** and D**1**, and whether touch occurs may be sensed according to whether a finger capacitance Cfig occurs.

[0073] FIGS. **8** and **9** illustrate a structure and operation of the touch panel TP of FIG. **5**, according to an example embodiment. Referring to FIGS. **5**, **8**, and **9**, the first sub sensing unit SENU**1** of the touch panel TP may be included in both of two display units DPU**1** and DPU**2** sharing the second electrode ELT**2**. Although FIG. **8** illustrates some display pixels DPIX of the display units DPU**1** and DPU**2**, additional display pixels may be included in the display units DPU**1** and DPU**2**.

[0074] As described above, the display unit DPU is activated by the display gate line DGL, and applies an image voltage Vimg corresponding to image data IDTA transmitted via source lines SOUL, to the first electrode ELT**1**. The source lines SOUL may include three lines, e.g., R, G, and B lines. Although not shown in FIG. **8**, the first electrode ELT**1** may be connected to a drain of a switching transistor ST of the display unit DPU. A voltage difference Vdiff between the first electrode ELT**1** and the second electrode ELT**2** changes a cell capacitance C_{ic} to drive a liquid crystal to correspond to the image voltage Vimg. If the second electrode ELT**2** is a common electrode, a common voltage Vcom is applied to the second electrode ELT**2**. A storage capacitor C_{st} of the display unit DPU is charged to correspond to the image voltage Vimg.

[0075] A first display gate line DGL**1** and a second display gate line DGL**2** are sequentially activated, a first display unit DPU**1** and a second display unit DPU**2** sequentially drive the liquid crystal, and then, the first sensor gate line SGL**1** is

activated. The second display gate line DGL2 may be the same as the second gate line GLIN2 of FIG. 1.

[0076] When the sensor gate line SGL is activated, the display gate line DGL2 is deactivated and the first electrode ELT1 is thus floated. The liquid crystal may be maintained in a state driven by the second display unit DPU2 (a voltage of a storage capacitor Cst of the second display unit DPU2) until a subsequent display gate line (third display gate line DGL3) is activated.

[0077] When the first sensor gate line SGL1 is activated, a voltage variation Vvar at the second electrode ELT2 due to generation of a finger capacitance Cfig is sensed as sensing current I_{sen} as described above. Although FIG. 8 illustrates some sensing pixels SPIX of the first sub sensing unit SENU1, additional sensing pixels may be included in the first sensing unit SENU1.

[0078] In FIG. 9, a gate voltage of the first sensing transistor SENT1 of the first sub sensing unit SENU1 may have a first level L1 when the finger capacitance Cfig is formed, and may have a second level L2 when the finger capacitance Cfig is not formed.

[0079] First reset transistors REST1*a* and REST1*b* of the first sub sensing unit SENU1 reset the second electrode ELT2 before and after a sensing operation of the first sub sensing unit SENU1 is performed. For example, the first reset transistors REST1*a* and the REST1*b* may reset the second electrode ELT2 with the common voltage Vcom.

[0080] After the first sensor gate line SGL1 is deactivated, the third display gate line DGL3 is activated and the display and sensing operations described above are repeatedly performed. However, as will be described below, the sensing operation of the second sub sensing unit SENU2 may be different from that of the first sub sensing unit SENU1. For convenience of explanation, the second sub sensing unit SENU2 is not illustrated in FIG. 8.

[0081] FIGS. 8 and 9 illustrate a case where one first sub sensing unit SENU1 is included in every two display units. However, the number of display units that share one first sub sensing unit SENU1 is not limited, and may vary according to desired touch sensitivity and display pixel size. For example, when a display pixel is small or high touch sensitivity is used, the number of display units that share one first sub sensing unit SENU1 may be greater than in a case illustrated in FIG. 8.

[0082] Also, one first sub sensing unit SENU1 may not be shared by two or more display units. As illustrated in FIGS. 10 and 11, one first sub sensing unit SENU1 may be included in each of display units. A case where one first sub sensing unit SENU1 is included in each of the display units may also be set according to touch sensitivity and display pixel size.

[0083] In the embodiment of FIG. 8, the first sub sensing unit SENU1 includes both the first reset transistors REST1*a* and REST1*b* that reset the second electrode ELT2 before a sensing operation of the first sub sensing unit SENU1 is performed, and the second electrode ELT2 is reset after the sensing operation of the first sub sensing unit SENU1 is performed and when the display gate line DGL3 is activated, but the example embodiments are not limited thereto.

[0084] Referring to FIGS. 12 and 13, a first sub sensing unit SENU1 of the touch panel TP may include only a first reset transistor REST1*a*, and may additionally include a display reset unit DRU. Thus, a second electrode ELT2 may be reset by the first reset transistor REST1*a* before a sensing operation of the first sub sensing unit SENU1 is performed, and may be reset by the display reset unit DRU in response to a display reset signal DRST after the sensing operation of the first sub sensing unit SENU1 is performed and when a display gate line DGL is activated. The display reset signal DRST may be transmitted to the display reset unit DRU by a control logic (not shown) that may be included in a touch screen apparatus THCA described below with reference to FIG. 33.

[0085] Examples of the first sub sensing unit SENU1 of FIG. 1 have been described above. Examples of the second sub sensing unit SENU2 of FIG. 1 will now be described.

[0086] FIGS. 14A-14B illustrate an object sensed by the second sub sensing unit SENU2 of FIG. 1. Referring to FIGS. 1 and 14A and 14B, sensing current I_{sen} sensed by the second sub sensing unit SENU2 may be a variation in current corresponding to a touch of light incident on the touch panel TP. The light incident on the touch panel TP may be light emitting from a light pen LPEN of FIGS. 14A-14B. A touch screen apparatus (not shown) including the touch panel TP may generate a touch event from a remote distance by using a light pen or the like. When light is incident on the touch panel TP as illustrated in FIG. 14B, current is generated by a photo thin-film transistor (TFT) which is a light-receiving device, and the second sub sensing unit SENU2 may sense the current.

[0087] Thus, the touch panel TP is capable of sensing not only optical touch but also physical touch as described above, and may thus by implementing a product employing a laser remote control technology, e.g., an electronic blackboard or a large-scale smart television (TV). Furthermore, since the touch panel TP is manufactured to be capable of sensing different types of touches, manufacturing costs are reduced, thereby securing competitive price. Also, since the touch panel TP may perform sensing at high speeds through current sensing other than charge sensing, the touch panel TP may be easily applied to a large-scale panel using a high frame frequency. Optical sensing performed by the second sub sensing unit SENU2 of the touch panel TP will be described below in detail.

[0088] FIG. 15 is a circuit diagram of the second sub sensing unit SENU2 of FIG. 1 that performs the sensing operation illustrated in FIGS. 14A-14B, according to an example embodiment. Referring to FIGS. 1 and 15, the second sub sensing unit SENU2 may include a second sensing transistor SENT2 and a second selection transistor SELT2. The second sensing transistor SENT2 may be a photo transistor such as shown in FIG. 14(*b*), or may be embodied as an oxide semiconductor transistor. The features of the oxide semiconductor transistor are described below. The transistors SELT1, SELT2, SENT1, and REST1 described above may also be oxide semiconductor transistors but are not limited thereto.

[0089] While a gate voltage that is lower than a threshold voltage is applied to the second sensing transistor SENT2, the second sensing transistor SENT2 senses a variation in a drain-source current according to whether light is incident thereon. One terminal, the other terminal, and a gate of the second sensing transistor SENT2 are connected to a gate line GLINn, the second selection transistor SELT2, and a gate line GLINn+1, respectively. The gate line GLINn may be the same as the third gate line GLIN3 of FIG. 1, and the gate line GLINn+1 may be the same as the fourth gate line GLIN4 of FIG. 1. As described above, the third gate line GLIN3 of FIG. 1 may be a sensor gate line that is activated during a sensing operation, and the fourth gate line GLIN4 may be a display gate line that is activated during a display operation.

[0090] One terminal, the other terminal, and a gate of the second selection transistor SELT**2** may be connected to a sensing line SLIN, the other terminal of the second sensing transistor SENT**2**, and the gate line GLINn, respectively.

[0091] When the gate line GLINn is activated and a voltage that is higher than the threshold voltage is thus applied to the gate of the second selection transistor SELT**2**, the second selection transistor SELT**2** is turned on. When the gate line GLINn+1 is deactivated, the second sensing transistor SENT**2** is turned off. Gate lines of the touch panel TP are sequentially activated such that only one of the gate lines is activated at a time. Thus, while the gate line GLINn is activated, the gate line GLINn+1 is deactivated. Thus, the second sensing transistor SENT**2** gated by the gate line GLINn+1 is turned off. As described above, the second sensing transistor SENT**2** may be a photo transistor embodied as an oxide semiconductor transistor.

[0092] Thus, sensing current I_{sen} corresponding to the drain-source current of the second sensing transistor SENT**2** flows from the source (the other terminal) of the second sensing transistor SENT**2** to the sensing line SLIN via the turned-on second selection transistor SELT**2**. The amount of the sensing current I_{sen} supplied to the sensing line SLIN from the second sensing transistor SENT**2** varies according to the intensity of light incident on the second sensing transistor SENT**2**, as illustrated in FIG. **16**.

[0093] When the gate line GLINn is deactivated and the gate line GLINn+1 is activated, the second selection transistor SELT**2** is turned off and the second sensing transistor SENT**2** is turned on to reset the second sensing transistor SENT**2** by a voltage applied to the gate line GLINn+1. Such a reset operation is performed to remove electric charges trapped in the second sensing transistor SENT**2** which is a photo transistor, as will be described in detail with reference to FIG. **16** below.

[0094] FIG. **16** is a graph showing the features of the second sensing transistor SENU**2** of FIG. **15**, according to an example embodiment. Referring to FIGS. **15** and **16**, at a point of time t**1**, light is incident on the second sensing transistor SENT**2** to increase an amount of drain-source current IDS of the second sensing transistor SENT**2**. Then, even though at a point of time t**2**, the incident light is discontinued, the amount of the drain-source current IDS is hardly reduced and is maintained to be substantially the same as when the light was incident on the second sensing transistor SENT**2**. Such a phenomenon occurs, since the second sensing transistor SENT**2** is embodied as an oxide semiconductor transistor having a channel layer formed of an oxide semiconductor and electric charges may be trapped in the channel layer or at a surface of the channel layer. The oxide semiconductor may include ZnO, InO, SnO, InZnO, ZnSnO, or InSnO, or may include a combination of ZnO, InO, SnO, InZnO, ZnSnO, or InSnO and at least one material selected from the group consisting of Hf, Zr, Ti, Ta, Ga, Nb, V, Al, and Sn.

[0095] For example, when light and a negative gate voltage are supplied to the second sensing transistor SENT**2** that is an oxide semiconductor transistor, holes generated in the channel layer due to the light may be moved to and trapped at the interface between the gate insulating film and the channel layer. The trapped electric charges may not be removed until a sufficient high positive (+) voltage is applied to a gate of the second sensing transistor SENT**2**. Thus, once the electric charges are trapped, the amount of the drain-source current I_{DS} may not be reduced even if the incident light is discontinued. The electric charges trapped in the second sensing transistor SENT**2** that is an oxide semiconductor transistor may be removed through the reset operation as described above.

[0096] A touch panel capable of sensing light uses a fine optical sensing device capable of sensing light. An example of the optical sensing device may be an amorphous silicon TFT (a-Si TFT). When light is sensed using such an oxide semiconductor transistor, electron mobility is high, the light can thus be easily sensed, and only a switch transistor (second selection transistor SELT**2** of FIG. **15**) for switching the oxide semiconductor transistor is used. Thus, when a touch panel is designed or produced, it is possible to remove limitations to increasing the size of the touch panel due to a parasitic capacitance and prevent a delay in a sensing operation.

[0097] FIG. **17** is a circuit diagram illustrating in detail an example of the touch panel TP of FIG. **1**. FIG. **18**A is a timing diagram illustrating an operation of the touch panel TP of FIG. **17**, according to another example embodiment. Referring to FIGS. **17** and **18**A, a first sub sensing unit SENU**1** and a second sub sensing unit SENU**2** may be the same as the first sub sensing unit SENU**1** of FIG. **6** and the second sub sensing unit SENU**2** of FIG. **15**, respectively, and are thus not described in detail here again.

[0098] When a first display gate line DGL**1** and a second display gate line DGL**2** are sequentially activated, a first display unit DPU**1** and a second display unit DPU**2** sequentially drive a liquid crystal (not shown) and a first sensor gate line SGL**1** is then activated. As a voltage applied to the first sensor gate line SGL**1** changes from logic low (L) to logic high (H) and the first sensor gate line SGL**1** is thus activated, the first selection transistor SELT**1** is turned on. Thus, a voltage variation Vvar in a second electrode ELT**2**, caused by a finger capacitance Cfig, is sensed as sensing current I_{sen} by a first sensing transistor SENT**1**. As described above, a gate voltage of the first sensing transistor SENT**1** may have a first level L**1** when the finger capacitance Cfig is formed and may have a second level L**2** when the finger capacitance Cfig is not formed.

[0099] When the voltage applied to the first sensor gate line SGL**1** changes again from the logic high H to logic low L and the first sensor gate line SGL**1** is thus deactivated, a third display gate line DGL**3** and a fourth display gate line DGL**4** are sequentially activated to perform a display operation. A reset operation of the first sub sensing unit SENU**1** when the third display gate line DGL**3** is activated is as described above and is not described here in detail.

[0100] Then, a second sensor gate line SGL**2** is activated. When a voltage applied to the second sensor gate line SGL**2** changes from logic low L to logic high H and the second sensor gate line SGL**2** is thus activated, a second selection transistor SELT**2** is turned on. Thus, sensing current I_{sen} corresponding to a variation in light sensed by the second sensing transistor SENT**2** is supplied to a sensing line SLIN. A reset operation of the second sub sensing unit SENU**2** when a fifth display gate line DGL**5** is activated is as described above and is not described again here.

[0101] FIG. **18**B illustrates a method of operating the touch panel TP according to an example embodiment. The method may be performed by the touch panel TP shown in FIG. **1** and the circuit diagram shown in FIG. **17**. At **1805**, the circuit receives a first gate voltage on a first gate line. At **1810**, the circuit receives a second gate voltage on a second gate line. At **1815**, the circuit performs a determination of whether a touch of a first type has occurred based on the received first and

second voltages. For example, a voltage variation Vvar in a second electrode ELT**2**, caused by a finger capacitance Cfig, is sensed as sensing current I_{sen} by a first sensing transistor SENT**1** and is supplied to a sensing line SLIN. At **1820**, the circuit receives a third gate voltage on a third gate line. At **1825**, the circuit receives a fourth gate voltage on a fourth gate line. At **1830**, the circuit performs a determination of whether a touch of a second type has occurred based on the third and fourth receiving. The second type is different than the first type. For example, a sensing current I_{sen} corresponding to a variation in light sensed by the second sensing transistor SENT**2** is supplied to a sensing line SLIN.

[0102] FIG. **19** is a cross-sectional view of a part of the touch panel of FIG. **17**. Referring to FIGS. **17** and **19**, a display unit DPU, a first sub sensing unit SENU**1**, and a second sub sensing unit SENU**2** are formed on a glass substrate. Gates G**1** to G**6** of a switching transistor ST of a display pixel DPIX of the display unit DPU, a first reset transistor REST**1**, a first sensing transistor SENT**1**, and a first selection transistor SELT**1** of the first sub sensing unit SENU**1**, and a second sensing transistor SENT**2** and a second selection transistor SELT**2** of the second sub sensing unit SENU**2** are formed; and active areas Active that are insulated from the gates G**1** to G**6** via insulators are respectively formed. The active areas Active may be electrically connected to source and drain electrodes S**1** and D**1** and the like.

[0103] For convenience of explanation, in FIG. **19**, sources and drains of the switching transistor ST, the second sensing transistor SENT**2**, and the second selection transistor SELT**2** are not illustrated. The first sub sensing unit SENU**1** and the second sub sensing unit SENU**2** that may not be connected to each other are illustrated to be disposed adjacent to each other. Although not shown in FIG. **19**, a gate, source, or drain of each of the transistors may be connected to the gates lines DGL**1** to DGL**5**, SGL**1**, and SGL**2** of FIG. **17** or the sensing line SLIN of FIG. **1**, via contacts (not shown). However, one terminal S**1** of the first reset transistor REST**1** is connected to a second electrode ELT**2**, a gate G**2** of the first sensing transistor SENT**1** is connected to the second electrode ELT**2**, and one terminal D**2** of the first sensing transistor SENT**1** is connected to one terminal S**3** of the first selection transistor SELT**1**.

[0104] FIG. **20** illustrates another example of a touch panel TP of FIG. **1**. While not shown in FIG. **20**, the touch panel TP' includes the gate driver **100**. Referring to FIGS. **1** and **20**, the touch panel TP' includes a sensing unit $SENU^1$ that includes at least one pair of sensing units and that may thus sense different types of touch events as described above. The sensing unit $SENU^1$ may include a first sub sensing unit $SENU1^1$ and a second sub sensing unit $SENU2^1$ that sense different objects at different times, in response to activation of different gate lines.

[0105] The first sub sensing unit $SENU1^1$ senses a first type of touch variation in response to activation of a gate line GLINn, outputs sensing current I_{sen} corresponding to the first type of touch variation to a sensing line SLIN, and is reset in response to deactivation of the gate line $GLIN_n$ and activation of a gate line $GLIN_x$. The second sub sensing unit $SENU2^1$ senses a second type of touch variation, which is different from the first type of touch variation, in response to activation of a gate line $GLIN_m$, outputs sensing current I_{sen} corresponding to the second type of touch variation to the sensing line SLIN, and is reset in response to deactivation of the gate line $GLIN_m$ and activation of the gate line $GLIN_x$.

[0106] The gate line $GLIN_n$ of FIG. **20** may be the same as the first gate line GLIN**1** of FIG. **1**, and the gate line $GLIN_m$ of FIG. **20** may be the same as the third gate line GLIN**3** of FIG. **1**. The gate line $GLIN_x$ of FIG. **20** may be the same as the second gate line GLIN**2** or the fourth gate line GLIN**4** of FIG. **1**.

[0107] For example, the gate line $GLIN_n$ and the gate line $GLIN_m$ may be disposed adjacent to each other. A common reset line $RLIN_n$ for resetting the first sub sensing unit $SENU1^1$ and the second sub sensing unit $SENU2^1$ may be connected to the same gate line $GLIN_x$. For example, the gate line $GLIN_x$ may be disposed adjacent to the gate line $GLIN_m$ or the gate line $GLIN_n$.

[0108] FIGS. **21**A-**21**B illustrate an object sensed by the first sub sensing unit SENU**1** of FIG. **20**. Referring to FIGS. **20** and **21**A-**21**B, sensing current I_{sen} sensed by the first sub sensing unit $SENU1^1$ may be a value indicating whether a cell capacitance corresponding to a variation in the distance between the first and second electrodes ELET**1** and ELET**2** of the touch panel TP', caused by a physical touch (e.g., touching a liquid crystal with a finger), changes. For example, it is assumed that as illustrated in FIG. **21**A, the distance between the first electrode ELET**1** and the second electrode ELET**2** when the touch panel TP is not physically touched is d**1**. The first electrode ELET**1** may be a pixel electrode and the second electrode ELET**2** may be a common electrode. As illustrated in FIG. **21**B, when the distance between the first electrode ELET**1** and the second electrode ELET**2** is reduced to d**2** due to a physical touch, a variation Δd in the distance between the first electrode ELET**1** and the second electrode ELET**2** becomes (d**1**−d**2**). Since a cell capacitance C_{LC} is inversely proportional to a distance, the cell capacitance C_{LC} changes to correspond to a variation in the distance between the first electrode ELET**1** and the second electrode ELET**2**. Locations of the first electrode ELET**1** and the second electrode ELET**2** are illustrated in FIGS. **21**A and **21**B for convenience of explanation, but example embodiments are not limited thereto. The first electrode ELET**1** and the second electrode ELET**2** may be disposed in the touch panel TP' as illustrated in FIGS. **3**A-**3**B.

[0109] FIG. **22** is a circuit diagram illustrating an example of the first sub sensing unit SENU**1**' of FIG. **20** that performs a sensing operation as illustrated in FIG. **21**. Referring to FIG. **22**, a first sub sensing unit SENU**1**' may include a first sensing transistor SENT**1**, a first selection transistor SELT**1**, and a first reset transistor REST**1**. The first sensing transistor SENT**1** senses a variation in a cell capacitance C_{LC}. One terminal, the other terminal, and a gate of the first sensing transistor SENT**1** are connected to a power supply voltage VDD source, one terminal of the first selection transistor SELT**1**, and a first node ND**1**, respectively. The first node has a voltage V_{nod} corresponding to the cell capacitance C_{LC}. Hereinafter, the voltage of the first node ND**1** will be referred to as 'node voltage V_{nod}'.

[0110] The node voltage V_{nod} may be expressed as follows:

$$V_{nod}=V_{reset}+(V_{COM}-V_{GL})\times C_{LC}/(C_{ref}+C_{LC}), \quad \text{[Equation 1]}$$

wherein 'V_{reset}' may denote a node voltage V_{nod} of a reset first node, similar to a first voltage V_1 illustrated in FIG. **27**, 'V_{COM}' denotes a voltage applied to the second electrode ELET**2** of FIG. **2**, 'V_{GL}' denotes a voltage applied to a gate line $GLIN_n$, and 'C_{ref}' denotes a reference capacitance.

[0111] FIG. **23** is a diagram illustrating the concept of the cell capacitance C_{LC} illustrated in FIG. **22**.

[0112] Referring to FIGS. **22** and **23**, a reference capacitance C_{ref} is a capacitance formed on a first layer LAY**1** between a gate GAT and a first electrode ELET**1** on a substrate SUB of the touch panel TP', and the cell capacitance C_{LC} is a cell capacitance formed on a second layer LAY**2** between the first electrode ELET**1** and a second electrode ELET**2**. The first layer LAY**1** may be a layer treated with a gate insulator and passivation. The second layer LAY**2** may be a layer filled with a conductive material. Locations of the first electrode ELET**1** and the second electrode ELET**2** illustrated in FIG. **23** are just illustrative and example embodiments are not limited thereto. In the touch panel TP', the first electrode ELET**1** and the second electrode ELET**2** may be disposed as illustrated in FIGS. **3**A-**3**B. FIG. **22** illustrates a case where the reference capacitance C_{ref} is formed between the first node ND**1** and an arbitrary gate line $GLIN_y$. An example of the arbitrary gate line $GLIN_y$ is described with reference to FIG. **25** below.

[0113] When a physical touch occurs as illustrated in FIG. **21**B to reduce the thickness of the second layer LAY**2**, the reference capacitance C_{ref} is a fixed value but a cell capacitance C_{LC} increases. Thus, a node voltage V_{nod} is increased. When the node voltage V_{nod} is greater than a threshold voltage of the first sensing transistor SENT**1**, the first sensing transistor SENT**1** is turned on to form drain-source current corresponding to a gate-source voltage of the first sensing transistor SENT**1**.

[0114] In FIG. **22**, one terminal, the other terminal, and a gate of the first selection transistor SELT**1** may be connected to a sensing line SLIN, one terminal of the first sensing transistor SENT**1**, and a gate line $GLIN_n$, respectively. The first selection transistor SELT**1** may supply drain-source current corresponding to a variation in a gate-source voltage of the first sensing transistor SENT**1** (variation in the node voltage V_{nod} of the first node ND**1**) to the sensing line SLIN, in response to activation of a first gate line.

[0115] One terminal, the other terminal, and a gate of the first reset transistor REST**1** may be connected to a gate of the first sensing transistor SENT**1**, the gate line $GLIN_n$, and a reset line $RLIN_n$, respectively. Thus, when the gate line $GLIN_n$ is deactivated and the reset line $RLIN_n$ is activated, the first reset transistor REST**1** is turned on to reset the node voltage V_{nod}. As described above, the reset line $RLIN_n$ may be connected to a gate line $GLIN_x$ and may thus be activated in the same manner as the gate line $GLIN_x$ is activated.

[0116] FIG. **24** is a circuit diagram of an example of the second sub sensing unit SENU**2**[1] of FIG. **20**. Referring to FIGS. **20** and **24**, the second sub sensing unit SENU**2** may include a second sensing transistor SENT**2** and a second selection transistor SELT**2**. The second sensing transistor SENT**2** may be a photo transistor embodied as the oxide semiconductor transistor of FIG. **14**B. As described above, the other transistors SELT**1**, SELT**2**, SENT**1**, and REST may also be oxide semiconductor transistors but the example embodiments are not limited thereto.

[0117] While a gate voltage that is lower than a threshold voltage is applied to the second sensing transistor SENT**2**, the second sensing transistor SENT**2** senses a variation in drain-source current according to whether light is incident thereon. One terminal, the other terminal, and a gate of the second sensing transistor SENT**2** are connected to a power supply voltage VDD source, the second selection transistor SELT**2**, and a reset line $RLIN_n$. One terminal, the other terminal, and a gate of the second selection transistor SELT**2** are connected to a sensing line SLIN, the other end of the second sensing transistor SENT**2**, and a gate line $GLIN_m$.

[0118] When the gate line $GLIN_m$ is activated to apply a voltage, which is equal to or higher than the threshold voltage, to the gate of the second selection transistor SELT**2**, the second selection transistor SELT**2** is turned on. On the other hand, when the reset line $RLIN_n$ is deactivated, the second sensing transistor SENT**2** is turned off. As described above, the reset line $RLIN_n$ is connected to a gate line other than the gate line $GLIN_m$. The gate lines of the touch panel TP are sequentially activated such that only one of the gate lines is activated at a time. Thus, while the gate line $GLIN_m$ is activated, the gate line connected to the reset line $RLIN_n$ are deactivated. Thus, the second sensing transistor SENT**2** gated by the reset line $RLIN_n$ is turned off.

[0119] Thus, sensing current I_{sen} corresponding to drain-source current of second sensing transistor SENT**2** flows to the sensing line SLIN via the turned-on second selection transistor SELT**2**, i.e., from the source (the other end) of the second sensing transistor SENT**2** to the sensing line SLIN. The second selection transistor SELT**2** may be turned off when the gate line $GLIN_m$ is deactivated, and may be turned on and reset when the reset line $RLIN_n$ is activated.

[0120] FIG. **25** is a circuit diagram illustrating in detail an example of the touch panel TP' of FIG. **20** including the first sub sensing unit SENU**1**' of FIG. **22** and the second sub sensing unit SENU**2**' of FIG. **24**. FIG. **26** is a timing diagram illustrating operations of the first and second sub sensing units SENU**1**' and SENU**2**' of FIG. **25**. Referring to FIGS. **25** and **26**, the touch panel TP' includes the first sub sensing unit SENU**1**' of FIG. **22** and the second sub sensing unit SENU**2**' of FIG. **24**, in which gates of a first selection transistor SELT**1** of the first sub sensing unit SENU**1**' and a second selection transistor SELT**2** of the second sub sensing unit SENU**2**' are connected to adjacent gate lines $GLIN_n$ and $GLIN_{n+1}$, respectively. For example, the gate line $GLIN_m$ of FIG. **24** may be the same as the gate line $GLIN_{n+1}$ adjacent to the gate line $GLIN_n$. The first sub sensing unit SENU**1**' and the second sub sensing unit SENU**2**' may sequentially perform a sensing operation (generation of sensing current I_{sen}) when the adjacent gate lines $GLIN_n$ and $GLIN_{n+1}$ are sequentially activated.

[0121] Reset lines $RLIN_n$ of the first sub sensing unit SENU**1**' and the second sub sensing unit SENU**2**' may be commonly connected to a gate line $GLIN_{n+2}$. For example, a gate line $GLIN_x$ connected to the reset line $RLIN_n$ of FIG. **22** and a gate line $GLIN_x$ connected to the reset line $RLIN_n$ of FIG. **24** may be commonly connected to the gate line $GLIN_{n+2}$. The gate line $GLIN_{n+2}$ may be located adjacent to the gate line $GLIN_{n+1}$. The first sub sensing unit SENU**1**' and the second sub sensing unit SENU**2**' may sequentially perform the sensing operation, and may be simultaneously reset in response to activation of the gate line $GLIN_{n+2}$.

[0122] A reference capacitor C_{ref} of the first sub sensing unit SENU**1**' included in the touch panel TP' of FIGS. **25** and **26** is connected to the gate line $GLIN_{n+1}$ but the example embodiments are not limited thereto. As described above, the reference capacitor C_{ref} of the first sub sensing unit SENU**1**' may be a gate line, e.g., a gate line $GLIN_{n-1}$ (not shown), among the two gate lines adjacent to the gate line $GLIN_n$, except for the gate line $GLIN_{n+1}$.

[0123] When a voltage applied to the gate line $GLIN_n$ changes from logic low L to logic high H and the gate line $GLIN_n$ is thus activated, the first selection transistor SELT**1** is

turned on to apply a variation (node voltage V_{nod}) in a cell capacitance C_{LC} sensed by the first sensing transistor SENT**1** to the sensing line SLIN (P**1**=Sensing**1**). When the voltage applied to the gate line $GLIN_n$ changes from logic high H to logic low L and the gate line $GLIN_n$ is thus deactivated, a voltage applied to the gate line $GLIN_{n+1}$ adjacent to the gate line $GLIN_n$ changes from logic log L to logic high H and the gate line $GLIN_{n+1}$ is thus activated to turn on the second selection transistor SELT**2**. Thus, a variation in light sensed by the second sensing transistor SENT**2** is supplied to the sensing line SLIN (P**2**=Sensing**2**).

[0124] In this case, as illustrated in FIG. **26**, the node voltage V_{nod} and the sensing current I_{sen} vary depending on whether a touch event occurs. If the gate line $GLIN_n$ is activated, a physical touch as illustrated in FIG. **21**B is sensed, the node voltage V_{nod} has a voltage corresponding to the logic high H, the gate line $GLIN_{n+1}$ is activated, and an optical touch as illustrated in FIG. **14**B is sensed, then the sensing current I_{sen} is maintained at logic high H.

[0125] When the gate line $GLIN_{n+1}$ is deactivated and the gate line $GLIN_{n+2}$ adjacent to the gate line $GLIN_{n+1}$ is activated, a first reset transistor REST**1** of the first sub sensing unit SENU**1**' and a second reset transistor REST**2** of the second sub sensing unit SENU**2**' are turned on to simultaneously perform the reset operation described above on the node voltage V_{nod} and the second sensing transistor SENT**2** (P**3**=Reset**1**&Reset**2**).

[0126] FIG. **27** is a graph showing a sensing operation of the touch panel TP of FIG. **20** according to another example embodiment. Referring to FIGS. **20** and **27**, the first sub sensing unit SENU**1**' of the touch panel TP' supplies sensing current I_{sen} corresponding to a variation ΔV in a gate-source voltage V_{GS} of the first sensing transistor SENT**1** that changes from a first voltage V**1** to a second voltage V**2** due to physical touch on the touch panel TP', to the sensing line SLIN. In this case, a node voltage V_{nod} (first voltage V**1**) when the first sensing transistor SENT**1** is not gated may be a negative (−) voltage, and a node voltage V_{nod} (second voltage V**2**) when a voltage of the first sensing transistor SENT**1** is increased due to the physical touch and the first sensing transistor SENT**1** is thus gated may be a positive (+) voltage. After the first sensing transistor SENT**1** senses the physical touch, the reset operation described above is performed to set a gate voltage (node voltage V_{nod}) of the second sensing transistor SENT**2** to be the first voltage V**1** that is a negative (−) voltage.

[0127] The touch panel TP senses an optical touch together with the physical touch. The second sub sensing unit SENU**2** of FIG. **27** supplies sensing current I_{sen} corresponding to a variation ΔI in drain-source current I_{DS} of the second sensing transistor SENT**2** that changes from first current I**1** to second current I**2** due to the optical touch, to the sensing line SLIN.

[0128] FIG. **28** is a circuit diagram of another example of a touch panel TP" of FIG. **1** having a different sensing unit SENU". While not shown in FIG. **28**, the TP" includes the gate driver **100**. FIGS. **29** and **30** illustrate a structure and operation of the touch panel TP" of FIG. **28**, according to another example embodiment. Referring to FIGS. **28** to **30**, the touch panel TP" may include a first sub sensing unit SENU**1**" and a second sub sensing unit SENU**2**" that sense different objects at different times, in response to activation of different gate lines, similar to the touch panel TP of FIG. **20**. However, in the touch panel TP" illustrated in FIGS. **28** and **29**, a first reset line $RLIN_n$ of the first sub sensing unit SENU**1**" and a second reset line $RLIN_{n+1}$ of the second sub sensing unit SENU**2**" are different from each other. For example, the first sub sensing unit SENU**1**" that outputs sensing current I_{sen} when a gate line $GLIN_n$ is activated is reset by a voltage applied to the first reset line $RLIN_n$ connected to a gate line $GLIN_m$. The second sub sensing unit SENU**2** that outputs the sensing current I_{sen} when the gate line $GLIN_m$ is activated is reset by a voltage applied to the second reset line $RLIN_{n+1}$ connected to a gate line $GLIN_l$.

[0129] The gate lines $GLIN_n$ and $GLIN_m$ of FIGS. **28** to **30** may be the same as the first gate line GLIN**1** and the third gate line GLIN**3** of FIG. **1**. The gate lines $GLIN_m$ and $GLIN_l$ of FIGS. **28** to **30** may be the same as the second gate line GLIN**2** and the fourth gate line GLIN**4** of FIG. **1**. In other words, the gate line $GLIN_m$ illustrated in FIGS. **28** to **30** may function as both a sensor gate line and a display gate line. This is because as illustrated in FIG. **31**, the sensing unit SENU is connected to a gate line to which a display unit DPU is connected in the touch panel TP of FIG. **28**, similar to the touch panel TP of FIG. **20**.

[0130] Referring to FIGS. **28** to **30**, a variation (node voltage V_{nod}) in a cell capacitance C_{LC} is sensed when the gate line $GLIN_n$ is activated (P**1**=Sensing**1**), and not only a variation in the intensity of light is sensed but also a first reset transistor REST**1** of the first sub sensing unit SENU**1** is reset when a gate line $GLIN_{n+1}$ is activated (P**2**=Sensing**2**&Reset**1**). When a gate line $GLIN_{n+2}$ is activated, a second sensing transistor SENT**2** of the second sub sensing unit SENU**2** is reset (P**3**=Reset**2**).

[0131] FIG. **31** is a circuit diagram of another example of the touch panel TP of FIG. **1**. Referring to FIG. **31**, in the touch panel TP, a sensing unit SENU is embodied together with display pixels as described above (in-cell type). FIG. **31** illustrates a case where each of gate lines is connected to display pixels, e.g., R, G, and B display pixels, and the sensing unit SENU. Thus, the touch panel TP may not be installed separately from a display panel (not shown). The touch panel TP according to the current embodiment may be easily embodied as an in-cell type by realizing a simple circuit capable of sensing different types of touches as described above.

[0132] FIG. **32** is a timing diagram illustrating an operation of the touch panel TP of FIG. **31** according to another example embodiment. Referring to FIGS. **31** and **32**, first to sixth gate lines GLIN**1** to GLIN**6** of the touch panel TP of FIG. **31** are respectively, sequentially activated points of time t**1** to t**6** to perform sensing and/or reset operations corresponding thereto as illustrated in FIG. **32**. For example, a sensing unit SENU connected to the first gate line GLIN**1** may be sensed when the first gate line GLIN**1** is activated, and a sensing unit SENU connected to the second gate line GLIN**2** may be sensed and the sensing unit SENU connected to the first gate line GLIN**1** may be reset when the second gate line GLIN**2** is activated. Similarly, a sensing unit SENU of the third gate line GLIN**3** may be reset and the sensing unit SENU of the second gate line GLIN**2** may be reset when the third gate line GLIN**3** is activated.

[0133] FIG. **33** is a block diagram of a touch screen apparatus THCA according to an example embodiment. Referring to FIG. **33**, the touch screen apparatus THCA may include a gate driver GDRV and a source driver SDRV that apply a gate voltage Vgat and a source voltage Vsou to a touch panel TP, such as that according to one of the above embodiments, respectively, and a signal output unit SOUT that receives

sensing current I_{sen} sensed by the touch panel TP and outputs a signal (data) corresponding to the sensing current I_{sen}.

[0134] The structures and operations of touch panel according to various example embodiments have been described above, but may be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein.

[0135] For example, FIG. **1** illustrates the gate lines connected to the first sub sensing unit SENU**1** and the second sub sensing unit SENU**2** but example embodiments are not limited thereto. As illustrated in FIG. **34**, a touch panel TP may include a display pixel array DPA and a sensing unit SENU on the same layer CL. The first sub sensing unit SENU**1** and the second sub sensing unit SENU**2** that are included in the sensing circuit SENU and sense different types of touch variations, may individually perform a sensing operation regardless of a connection among the first and second sensing units SENU**1** and SENU**2** and gate lines. In FIG. **34**, the layer CL may be the same as the layer CL illustrated in FIG. **2**A. The number of the first sub sensing units SENU**1** may be equal to the number of the second sub sensing units SENU**2** or greater than or less than the number of the second sub sensing units SENU**2**. Accordingly, example embodiments set forth herein should be considered in descriptive sense only and not for purposes of limitation.

[0136] As described above, a hybrid touch panel capable of performing optical sensing and capacitance sensing, a hybrid touch screen apparatus, and a method of driving the hybrid touch screen according to the one or more of the above embodiments of the example embodiments are capable of efficiently sensing touch at a long distance and a short distance.

[0137] Furthermore, a touch panel may be embodied as an in-cell touch screen capable of performing different types of sensing operations by embodying a sensing unit capable of performing different types of sensing operations as a simple circuit.

[0138] Also, it is possible to more efficiently remove limitations to increasing the size of the touch panel due to a parasitic capacitance and prevent a delay in a sensing operation by performing optical sensing by using an oxide photo sensor transistor.

[0139] It should be understood that the example embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other example embodiments.

What is claimed is:

1. A touch panel comprising:

a sensing unit including,

a first sub sensing unit configured to output a first sensing current in response to a voltage of a first gate line and configured to reset in response to a voltage of a second gate line, the first sensing current corresponding to a first touch type, and

a second sub sensing unit configured to output a second sensing current in response to a voltage of a third gate line and configured to reset in response to a voltage of a fourth gate line, the second sensing current corresponding to a second touch type which is different than the first touch type; and

a display unit configured to generate an image voltage corresponding to image data to be displayed, in response to at least one of the voltages of the first to fourth gate lines.

2. The touch panel of claim **1**, further comprising:

first and second electrodes, the first electrode being a pixel electrode configured to receive the image voltage, the second electrode being a common electrode configured to receive a common voltage.

3. The touch panel of claim **2**, wherein the first sub sensing unit and the display unit are coupled to the second electrode.

4. The touch panel of claim **2**, wherein the first sub sensing unit includes an oxide transistor configured to output the first sensing current corresponding to a voltage change at the second electrode.

5. The touch panel of claim **1**, wherein the second sub sensing unit includes an oxide transistor configured to output the second sensing current in response to the voltage of the third gate line.

6. The touch panel of claim **1**, wherein the display unit and the first sub sensing unit are in the same array.

7. The touch panel of claim **1**, wherein the first touch type indicates whether the touch panel is physically touched.

8. The touch panel of claim **7**, wherein the second touch type denotes a variation in current corresponding to a touch of light incident on the touch panel.

9. The touch panel of claim **1**, wherein the first to fourth gate lines are different gate lines.

10. A touch screen apparatus, comprising:

a touch panel including,

a first sub sensing unit configured to output a first sensing current, and

a second sub sensing unit configured to output a second sensing current,

wherein the first sensing current corresponds to a first touch type,

wherein the second sensing current corresponds to a second touch type,

wherein the second touch type is different than the first touch type, and

wherein the second sub sensing unit includes an oxide transistor configured to output the second sensing current.

11. The touch screen apparatus of claim **10**, wherein the touch panel further includes:

first and second electrodes, the first electrode being a pixel electrode configured to receive an image voltage, the second electrode being a common electrode configured to receive a common voltage; and

a display unit configured to generate the image voltage corresponding to image data to be displayed, the first sub sensing unit and the display unit being coupled to the second electrode.

12. The touch screen apparatus of claim **11**, wherein the first sub sensing unit includes an oxide transistor configured to output the first sensing current corresponding to a voltage change at the second electrode.

13. The touch screen apparatus of claim **11**, wherein

the first sub sensing unit is configured to output the first sensing current in response to a voltage of a first gate line and configured to reset in response to a voltage of a second gate line,

the second sub sensing unit is configured to output the second sensing current in response to a voltage of a third gate line and configured to reset in response to a voltage of a fourth gate line, and

the display unit is configured to generate the image voltage in response to at least one of the voltages of the first to fourth gate lines.

14. The touch screen apparatus claim **13**, wherein the first to fourth gate lines are different gate lines.

15. The touch screen apparatus of claim **11**, wherein the display unit and the first sub sensing unit are in the same array.

16. The touch screen apparatus of claim **10**, wherein the first touch type indicates whether the touch panel is physically touched.

17. The touch screen apparatus of claim **16**, wherein the second touch type denotes a variation in current corresponding to a touch of light incident on the touch panel.

18. A method of controlling a touch panel, the method comprising:

controlling first and second sensing units such that one of the first and second sensing units is active,

wherein the first sensing unit is configured to sense a first touch type of the touch panel,

wherein the second sensing unit is configured to sense a second touch type of the touch panel, and

wherein the first touch type is different than the second touch types.

19. The method of claim **18**, wherein the first touch type is a physical touch.

20. The method of claim **19**, wherein the second touch type is light incident on the touch panel.

21. The method of claim **18**, wherein the controlling includes,

first resetting the first sensing unit;

activating a first display unit of the touch panel during the first resetting; and

activating the second sensing unit after resetting the first sensing unit.

22. The method of claim **21**, wherein the controlling includes,

second resetting the second sensing unit; and

activating a second display unit during the second resetting.

23. The method of claim **18**, wherein the controlling includes,

activating the first sensing unit;

resetting the first sensing unit; and

activating the second sensing unit during the resetting.

24. The method of claim **18**, wherein the controlling includes,

first providing a first gate voltage on a first gate line;

activating the first sensing unit based on the first providing;

second providing a second gate voltage on a second gate line; and

deactivating the first sensing unit based on the second providing.

25. The method of claim **24**, wherein the controlling includes,

third providing a third gate voltage on a third gate line;

activating the second sensing unit based on the third providing;

fourth providing a fourth gate voltage on a fourth gate line; and

deactivating the second sensing unit based on the fourth providing.

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